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THE RAPID GROWTH OF BIRDS.*

By B. S. Bowdish.

Only those who have followed the household cares of a pair of birds, from their commencement to the time that the parents were able to turn out into the world a brood of independent, self-sufficient young, realize how marvelously rapid is the development of the offspring, both in and out of the egg. The power of flight, and in many cases protective coloration, have done much to aid adult birds in the matter of self-preservation, but the dangers that beset them during the period of reproduction are so great that were this period not shortened to a minimum they could hardly hold their place in the battle of life.

Such birds as some of the plovers and sandpipers, starting from winter homes in South America, journey to the far frozen North to rear their young, and then return again. In the high, cold latitudes, where these birds breed, the summer is short. The birds arrive late and depart early. Some of these long distance travelers are among the latest spring and earliest fall migrants. Thus the period allowed them for the rearing of their young is brief, and development must be rapid. But there is plenty of reason why rapid development is necessary, even among birds whose breeding season is sufficiently long to permit the rearing of two or three broods. The dangers that beset the birds' home, from the laying of the first egg to the time when the youngsters leave it, are manifold. Hawks, snakes, cats, and many predaceous mammals, such as weasels and minks, skunks and foxes, are liable at any moment to seize the mother on the nest, or, failing that, to devour the contents, whether eggs or young. In a general way it may be said that such dangers increase from the time of the hatching of the young till they leave the nest, and they are far from safe even then.

Then the chances of the weather play a very important part. Prolonged dry or wet weather often produces great mortality among young birds, as instanced in the summers of 1903 and 1904.

Only those who have had nests under observation realize how many tragedies enter into this important period of birds' lives, how many fruitless attempts are made to rear young.

Last summer one of the nests which I had under observation was that of a blue-winged warbler. I do not think I should ever have found it had I not happened to see the female carrying a large dead oak leaf, which was, perhaps, destined to be the corner-stone of the edifice she erected to hold her hopes and cares. This chance observation gave me the clue that I acted on a few days later when I searched the locality. In a wild little corner of slashing bordering a piece of woods were a few small scattered cedars. Near the base of one of these I found the beautiful little nest, almost entirely roofed over by a dead oak leaf. I do not think I ever saw a more admirably situated nest, or one more perfectly concealed. I congratulated myself that here would be an opportunity to observe the housekeeping of a bird whose habits during nidification I was unfamiliar with.

At the time of finding, the nest was newly completed, and contained no eggs. Three days later there were two eggs, and for the next three days an egg was added each day. The last egg was deposited on the 23d of May, and on June 3 I found the young hatched. On the 4th something had torn away the protecting cover leaf and the nest was empty, while the birds were crying about in distress. I thought it probable that a snake had taken the young, and concluded to

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YOUNG FIELD SPARROW AND EGG THE THIRD DAY.

YOUNG BROWN THRASHER THE THIRD DAY.

FEMALE BROWN THRASHER INCUBATING EGGS.

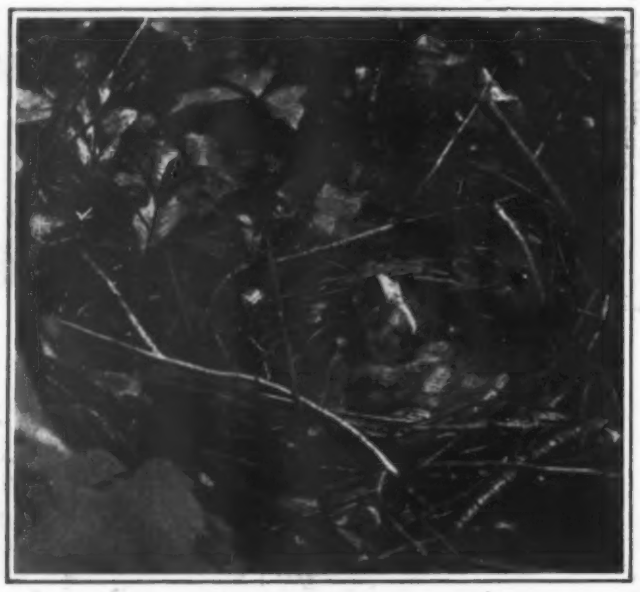
NEST AND EGGS OF BROWN THRASHER.

preserve the nest. On lifting it I found, directly beneath it, one poor little babe that still showed signs of life, and in the hope that the mother might brood it I hastily replaced nest and baby and hurried away, after assuring myself that no more of the babies were concealed about. A visit the following morning revealed the faithful little mother brooding her one remaining baby, and up to the 9th, on which date I photographed it, the survivor was doing well. On the 14th the nest was empty, and although this was certainly rapid development, I hope that the young blue-wing had developed sufficiently to leave the nest of his own volition. If he did escape a tragic fate, on what a slender thread his life hung when I found him under the nest! An hour later and the whole brood would have perished, instead of four-fifths of it.

At the same time that I was conducting my studies of the blue-winged warblers I had under observation nests of hooded and chestnut-sided warblers, chat, northern yellow-throat, and oven-bird. Something robbed the nests of chat, yellowthroat, and ovenbird before the eggs had hatched, and the young chestnut-sides disappeared soon after hatching. These are only a few instances of many noted in one season.

Birds choose with careful judgment the site for a nest. Natural concealment, material in harmony with surroundings, and often great care in approaching the nest, are all means toward the safeguarding of the nest and its contents, but even with all precaution the birds' efforts are often frustrated, and that, too, when success has almost crowned them. Thus it is seen how essential it is that the period of special danger be reduced to the shortest possible duration.

Where the period of incubation of any species is of more than fourteen days' duration it is usually found that special safeguards exist to offset it. Thus, in the case of hawks and owls, the nest is usually nearly or quite inaccessible. On the other hand, in the case of grouse, bobwhites, sandpipers, plovers, snipe, and



NEST AND YOUNG OF BROWN THRASHER ABOUT THREE DAYS OLD.

others, every item in the way of protective coloration is brought into play to assist an otherwise hopelessly defenseless bird. Parent, nest, eggs, young, all blend perfectly with surroundings, and even the skilled, keen eye of the eagle is often deceived. And another of nature's provisions to compensate the grouse and bobwhite for loss is the large laying, sometimes four or five times the number of eggs deposited by birds less beset by danger. In the case of such birds as those just mentioned there is also a special provision for the protection of the young.

They belong to the class of birds called precocious, the young being covered with down, and, running almost from the moment they are hatched, they leave the nest from that time and hide themselves with astonishing dexterity at the slightest indication of danger.

Among young birds thus gifted with special provisions, and a natural instinct tending strongly to self-preservation, there is not the need for rapid development that there is among birds hatched naked, blind, and absolutely helpless, nor is such rapid development usually found.

In the majority of small birds, eleven to fourteen days seem to be the usual period of incubation, and eight to fourteen days the period thereafter, during which the young remain in the nest. The dangers to which birds are subjected during the period of nidification are innumerable.

INSECT ENGINEERING.

ONE of the most interesting books in natural history is a work on "Insect Architecture," by Rennfe. But if the architecture of insect homes is wonderful, the engineering displayed by these creatures is equally marvelous. Long before man had thought of the saw, the saw-fly had used the same tool, made after the same fashion, and used in the same way for the purpose of making slits in the branches of trees so that she might have a secure place in which to deposit her eggs. The carpenter bee, with only the tools which nature has given her, cuts a round hole, the full diameter of her body, through thick boards, and so makes a tunnel by which she can have a safe retreat, in which to rear her young. The tumble-bug, without derrick or machinery, rolls over large masses of dirt many times her own weight, and the sexton beetle will, in a few hours, bury beneath the ground the carcass of a comparatively large animal. All these feats require a degree of instinct which in a reasoning creature would be called engineering skill, but none of them are as wonderful as the feats performed by the spider. This extraordinary little animal has the faculty of propelling her threads directly against the wind, and by means of her slender cords she can haul up and suspend bodies which are many times her own weight.

Some years ago a paragraph went the rounds of the papers in which it was said that a spider had suspended an unfortunate mouse, raising it up from the ground, and leaving it to perish miserably between heaven and earth. Would-be philosophers made great fun of the statement, and ridiculed it unmercifully. It might have been true.

Some years ago, in the village of Havana, in the State of New York, a spider entangled a milk-snake in her threads, and actually raised it some distance from the ground, and this, too, in spite of the struggles of the reptile, which was alive.

By what process of engineering did the comparatively small and feeble insect succeed in overcoming and lifting up, by mechanical means, the mouse or the snake? The solution is easy enough if we only give the question a little thought.

The spider is furnished with one of the most efficient mechanical implements known to engineers viz., a strong elastic thread. That the thread is strong is well known. Indeed, there are few substances that will support a greater strain than the silk of the silkworm, or the spider, careful experiments having shown that for equal sizes the strength of these fibers exceeds that of common iron. But notwithstanding its strength, the spider's thread alone would be useless as a mechanical power if it were not for its elasticity. The spider has no blocks or pulleys, and, therefore, it cannot cause the thread to divide up and run in different directions, but the elasticity of the thread more than makes up for this, and renders possible the lifting of an animal much heavier than a mouse or a snake. This may require a little explanation.

Let us suppose that a child can lift a six-pound weight one foot high and do this twenty times a minute. Furnish him with 350 rubber bands, each capable of pulling six pounds through one foot when stretched. Let these bands be attached to a wooden platform on which stands a pair of horses weighing 2,100 pounds, or rather more than a ton. If now the child will go to work and stretch these rubber bands, singly, hooking each one up, as it is stretched, in less than twenty minutes he will have raised the pair of horses one foot.

We thus see that the elasticity of the rubber bands enables the child to divide the weight of the horses into 350 pieces of six pounds each, and at the rate of a little less than one every three seconds, he lifts all these separate pieces one foot, so that the child easily lifts this enormous weight.

Each spider's thread acts like one of the elastic rubber bands. Let us suppose that the mouse or snake weighed half an ounce and that each thread is capable of supporting a grain and a half. The spider would have to connect the mouse with the point from which it was to be suspended with 150 threads, and if the little quadruped was once swung off his feet, he would be powerless. By pulling successively on each thread and shortening it a little, the mouse or snake might be raised to any height within the capacity of the building or structure in which the work was done. So that to those who have ridiculed the story we may justly say: "There are more things in heaven and earth than are dreamed of in your philosophy."

What object the spider could have had in his work it is difficult to see. It may have been a dread of the harm which the mouse or snake might work, or it may have been the hope that the decaying carcass would attract flies which would furnish food for the engineer.—From Phin's "Seven Follies of Science." D. Van Nostrand Company, Publishers.

THE DISCOVERY OF THE SOURCE OF THE ZAMBESI RIVER.

AN important work in African exploration, of great value to geographical knowledge concerning that continent, has been completed by Col. Colin Harding, who has discovered the source of the great Zambesi River. During this journey the expedition covered 8,000 miles, the greater part of which was through unknown country. Col. Harding was appreciably assisted on this momentous undertaking by Lewanika, the native king of Barotzeland, who transmitted orders to the various district chieftains by means of phonographic records, urging them to assist the party by every means in their power. Col. Harding attributes the success of his enterprise in no small measure to the phonograph, for when the unsophisticated chieftains listened to the royal commands of their august king proceeding from what they described as the "speaking iron" they were struck dumb with amazement and awe, and followed the words as they were produced, with gaping mouths, expecting every minute to see the form of their sovereign emerge from the instrument.

The expedition set out from Lewanika's capital with the Zambesi River in full flood, and the country inundated as far as the eye could reach. The party during their progress down the river were considerably disturbed by the huge herds of hippopotami infesting that region, the animals rushing at the boat and more than once capsizing the occupants, who, floundering in the water, were menaced with a new danger, as the water was alive with crocodiles.

For six days the party traveled through flooded country, and then they issued upon an extremely well wooded region. The heat was terrific, and the tropical rains which were then raging were of almost unparalleled fury. The party found that during the wet season business among the natives is practically at a standstill. The inhabitants regard the advent of the rain with philosophic calmness. They simply wrap themselves in their blankets and go to sleep during the rainfall, quite regardless of their duties.

The party made a short detour from the river in order to visit Queen Nyakatoro, who is all-powerful in this district, in order to seek her assistance so as to facilitate their progress. This mission completed, they returned to the river and resumed their way. Rain fell incessantly, and these conditions prevailed until the famous, but little-known, Makesh Rapids were reached, though traveling was a matter of difficulty and accompanied by many privations. At this point the leader of the party, accompanied by his brother and a few natives, left the boats and pushed forward on foot. The country was exceedingly rough. The Zambesi above this point is fed by innumerable small tributaries or torrents and the country through which they pass is either deep malodorous swamps or towering, damp, jungle-like grass. Under these conditions progress was not only slow, but arduous. The small tributaries run very swiftly and the water is blackish in color and quite unpalatable.

To aggravate the difficulties, two of the Indunas commanded by Lewanika to accompany Col. Harding wherever he went, under all circumstances, resolutely refused to proceed any farther. The leader was thus placed in an awkward predicament, as this decision of the Indunas left him and his brother practically alone in an unknown country, hundreds of miles from the nearest signs of civilization. However, he refused to turn back, and as three natives promised to remain faithful he decided to push on with all speed, though he warned the refractory Indunas that their rebellious conduct would be reported to King Lewanika on his return and that they would meet with the severest punishment.

This reprimand was ineffective; so owing to the reduced number of the party, tents, bedding, clothing, and other equipment were abandoned, the party only carrying the smallest supplies of food, the scientific instruments, and their rifles. But the expedition soon encountered fresh troubles. The rations were quickly exhausted, and they soon expended all their available articles for bartering with the natives, who, although possessing ample quantities of food, were not inclined to dispose of them except by purchase.

Consequently the party were soon reduced to sore straits. They were afflicted with hunger, and as they had subsisted on short rations for some days, the members were becoming faint and weary. At last they were at the end of their resources, and were vaguely speculating as to how they could obtain some food the next day, when one of the party, who was of a humorous disposition, determined to entertain the natives and thus gain some supplies. The following day when they entered a village, almost famished and exhausted, this "boy" attired himself as best he could with the few facilities at his command in the garb of a clown. He wound a glaring red handkerchief around his head, assumed a variety of ridiculous poses, indulged in fantastic dances and wild contortions or gymnastic feats. The natives crowded around the impromptu entertainer and were so highly amused that

they gave him enough food to last the party for three meals.

Meanwhile Col. Harding, with the assistance of his medicine chest, posed as a quack. He announced that he was prepared to prescribe for any who were sick, and the astonished natives soon produced a vast number of the afflicted. Many were suffering from only petty complaints and his cures of their ailments earned him the gratitude of the village, so that food was soon obtained in abundance.

In this manner the expedition pushed forward, and at last, after weeks of suffering, hardships, and the surmounting of innumerable difficulties they gained their goal—the source of the Zambesi River. It rises in a number of springs in the interior of Barotzeland, in the midst of a jungle. The trees are most luxuriant and are interlaced with thick creepers. The soil is unusually fertile, the bracken, plants, and fungi thriving in the shady hollow in abundance. The head of the river was thoroughly surveyed and considerable scientific and topographical data was secured. The expedition then retraced their steps, completing their survey and mapping out the numerous tributaries between the source and the Victoria Falls, as well as the Kaapenda or Makesh Rapids.

MANUFACTURE AND USE OF CONCRETE PILES.*

By HENRY LONGCOPE.

ALL of us have frequently seen piling used in many ways, and if my own experience is a criterion few of us have ever given this matter serious consideration and have taken the whole subject as a matter of course; but when we go into closer investigation we find that piling has an ancient and honorable history, beginning with the prehistoric race of Lake Dwellers, who at one time inhabited one portion of Europe, and traces of their ancient foundations have been discovered from time to time, showing that the pile played an important part in their social economy. It is probable they drove their piles with crude instruments, some distance from the shore, in order to protect themselves from land attacks by their enemies. Through the natural course of evolution, the crude idea was perfected by engineers, who saw that wooden piles were subject to decay and the attacks of the teredo worm, and as a consequence sought a material that was more substantial.

The first innovation was the sand pile, produced by driving a wooden form in the ground and withdrawing the same, the hole being filled with moist sand well rammed. The next method adopted was to drive a metal form into the ground and after withdrawal to fill the hole with concrete; but this was not successful, as it was open to the serious objection that on withdrawing the form the ground would collapse before the concrete could be inserted. Still another method was introduced, which consisted of dropping a cone-shaped piece of metal, weight five tons, a number of times from a considerable height, in order to form a hole, which was afterward filled with concrete. This method never passed the experimental stage. Later a plan was devised to mold a pile, using concrete, reinforcement sometimes also being used. This pile was allowed to stand until perfectly hard, when it was driven in a similar manner as now in vogue. To prevent the concrete pile from injury, a drive-head or cap was so arranged as to deaden the force of the hammer blow. Gilbreth uses a molded taper pile, cast with a core hole the entire length of the pile, which is jetted down by a water jet and finally settled by hammer blows. Still another method is used by Raymond. Under this system piles are usually put in by either of two methods, the jetting method or the pile core method. The water jet system is used only where the material penetrated is sand, quicksand, or soft material that will dissolve and flow up inside the pile when the water is forced through the pipe, thus causing the shell to settle until it comes in contact with the next shell, and so on until the desired depth has been reached. The shells are filled with concrete simultaneously with the sinking process, and when necessary spreaders are attached to keep the hole in perfect line with the pipe. The ½-inch pipe is left in the center of the pile and gives it greatly increased lateral strength. If desired, the lateral strength may be further increased by inserting rods near the outer surface of the concrete. By this method, piles of any size up to two feet in diameter at the bottom and four feet at the top can be put through any depth of water and to a suitable penetration in sand or silt (water sediment).

The pile-core method is the one most generally used for foundation work and consists of a collapsible steel pile core, conical in shape, which is incased in a thin, tight-fitting metal shell. The core and shell are driven into the ground by means of a pile driver. The core is so constructed that when the desired depth has been reached it is collapsed and loses contact with the shell, so that it can be easily withdrawn, leaving the shell or casing in the ground, to act as a mold or form for the concrete. When the form is withdrawn, the shell or casing is filled with carefully mixed Portland cement concrete, which is thoroughly tamped during the filling process.

The simplex system uses another method in which the driving form consists of a strong steel tube, the lower end of which is fitted with powerful tooth jaws, which close together tightly, with a point capable of penetrating the soil when driven and also capable of opening automatically to the full diameter of the tube while being withdrawn. The point of the form closely resembles the jaws of an alligator, and was so named by the colored laborers. At the same time the form is being withdrawn, the concrete is deposited. The form, as carried out in actual practice, is constructed as follows: A stock length (about 20 feet) of 15 inches outer diameter pipe ½-inch metal is reinforced at the upper end by means of a band of ½-inch boiler steel, 18 inches wide, rolled into a cylinder to fit tightly around the pipe and riveted to it by means of three rows of 1-inch rivets, 8 rivets to the row. The rivets are countersunk and have slightly oval shaped heads. This band has been found necessary to prevent the upsetting action of the hammer, and its depth, 18 inches, has been found by practice to be the minimum to prevent the buckling of the tube, although it seems well nigh impossible to construct a form which will entirely resist the repeated blows of the heavy hammer, the only solution being to build all of the apparatus of such rugged nature as to reduce the punishment to a minimum. Four large holes are bored 90 degrees apart through the band and pipe, to accommodate the 2-inch pins which connect the pulling tackle to the form.

The lower end of the pipe is riveted to a cast steel sleeve, having the same inside diameter as the pipe, but of 1½ inches thick metal, making the outside diameter 17 inches; the pipe is turned off true and fits with a driving fit into an 8-inch deep socket turned into the sleeve. Two rows of twelve 1-inch countersunk rivets with flattened heads connect the sleeve to the pipe. To this sleeve are attached two cast-steel jaws in such a manner as to permit them to swing freely. These jaws are segments of a true cylinder, the same size as the sleeve, namely, 14 inches inside diameter and 17 inches outside diameter, formed by two planes cutting in at approximately 30 degrees to the axis, and the second at right angles to the first and intersecting a little short of the axis. When brought together they form a clam shell point, absolutely tight and well adapted for penetrating the soil, but when hanging open they form a true cylinder of the full opening of the pipe. The interlocking of the jaws binds them together so that they act as one solid piece. The jaws are usually closed together and held by two small tapered pins, or a small clamp, which is destroyed during the driving and comes off when pulling the form from the ground.

The driving form consists of a stock length about 22 feet of large diameter pipe, reinforced with a band and fitted at the bottom with an alligator point. Additional lengths can be easily coupled by means of a band and rivets.

The pile driver used generally is similar to that used in driving ordinary wooden piles. A sliding purchase cap is arranged near the top of the driver and from it is suspended the pulling tackle, consisting of a quadruple steel block and a quintuple steel fall rove with a ⅝-inch plow steel wire rope, which runs over a single steel block and thence to the engine.

The hammer weighs 3,000 pounds, and the engine is any style of an approved type hoisting engine.

On the top of the driver are mounted three sheaves, the middle one for the 1½-inch hammer line and one on either side for the bucket line and the rammer line, respectively.

The pile is produced in this way: the driving form is swung up into the leads, with closed jaws; it is then lowered until it rests on the ground and has buried its nose in the soil. The pins are removed, the pressure of the soil holding the jaws together. On the top of the form is placed a steel drive-head with a tenant underneath to engage the pipe and provided on the top with an oak block to take the shock of the blow. The form is then driven to the required depth; the hammer with the drive-head attached is raised to the top of the leads, and toggled by swinging out the purchase cap carrying the pulling tackle. The fall is connected to the driving form and made ready for pulling it out of the ground. The rammer is a cylinder of cast iron 6 inches in diameter and weighs 30 pounds. This is lowered to the bottom of the form and a target is fastened in the rope flush with the top of the form. The rammer is raised half way up in the tube and a bucketful of concrete, which makes about 4 feet of pile, is hoisted in a bucket having a falling bottom, and emptied down the tube, striking the bottom with considerable impact. The rammer is lowered until it rests on the concrete, which would show the target about 4 feet above the top of the form; the form is pulled up until the target on the rammer line is 1 foot above the top of the form, which indicates that the jaws have opened and the concrete has passed through with the exception of a 1-foot head of concrete left in the form to prevent any particle of soil from getting into the concrete; the rammer is raised and let fall frequently to insure perfect ramming; then the rammer is raised half way up in the tube as before, and a second bucketful of concrete is emptied and the process is repeated until the hole has been filled and the form withdrawn.

The concrete used consists of 1 part Portland cement, 2½ sand and 5 parts broken stone, graded.

A modification of the method just described is to fill the form with the required amount of concrete, sufficient to make a complete pile, and a ramrod, which is merely a piston head with a rod fastened to it, upon which the hammer is lowered, but not struck; the form is then pulled and the hammer gradually settles, showing that the concrete is spreading out below, as the form is withdrawn, or, in other words, filling up the entire space previously occupied by the form.

In order to prevent voids another precaution is taken by furnishing the men with comparative tables, indicating the amount of concrete which should be inside the form, in order to make the required length of finished pile. If, on raising the form, the concrete should slop over, it would show that voids existed, and therefore the personal equation would be present here, as it is in all other operations.

In certain conditions of soil, such as deep fills of rubbish, cinders, or light, loose materials, a cast-iron point, generally of a similar shape to the alligator point, is used. There is no sleeve or jaws whatever on the end of the form, there being nothing but the plain length of pipe. The cast iron pipe is located on the proper center, on the ground where the hole is to be driven, the pipe form is lowered over this point and driven to the required depth; the method of withdrawing the form and filling is exactly the same as the method before described for alligator points, except in the case of the cast iron point, which remains in the ground, as obviously it cannot be withdrawn.

It is so evident that concrete is vastly superior to wood in the construction of piles that it is almost superfluous to mention the points of superiority. Concrete is not subject to rot or the ravages of the teredo worm, neither can the piles constructed of concrete be destroyed by fire, and no cost is attached for repairs. While it is not possible to give accurate statistics as to the life of a wooden pile, as it varies so much under different conditions, yet we know that in some cases they are rendered worthless in a very few years, especially when the material which surrounds them is composed of rotted vegetation, or where the pile is exposed by the rise and fall of tides. It is also impossible to state the exact cost of a concrete pile, as it varies also according to conditions. Ordinarily speaking, a concrete pile will cost from one and one-half times to two times as much as a wooden pile; but in order to illustrate where a saving can be made, the following extract from a letter to the Raymond Concrete Pile Company, under date of May 24, 1905, relative to the piles which they drove at the United States Naval Academy at Annapolis, Md., is given, viz.:

"The original plans called for 3,200 wooden piles cut off below low water with a capping of concrete. To get down to the low water level required sheet piling, shoring and pumping, and the excavating of nearly 5,000 cubic yards of earth. By substituting your concrete piles, the work was reduced to driving 850 concrete piles, excavating 1,000 cubic yards of earth and placing of 1,000 cubic yards of concrete."

In the work mentioned, the first estimate for wooden piles placed the cost at $9.50 each, while the estimate for concrete piles was placed afterward at $20 each, yet the estimate based on the use of wood piles aggregated $52,840, while the estimate based on the use of concrete piles was $25,403, or a total saving in favor of concrete of over $27,000.

One question which arose in my mind when I first started my investigation was whether the pile when completed was one solid mass, or whether it was full of voids or soil. In several instances the piles were uncovered to their full depth, and they were found to be perfectly sound in every particular. By surrounding the operation with the safeguards provided, it is almost impossible to make a faulty pile. The concrete is made as wet as good practice will allow. Constant ramming and dropping the concrete from a considerable height tend to the assurance of a solid mass, then the target on the ramming line or the introduction of an electric light into the form shows what is being done at the bottom of the form.

* Paper read before the Cement Users' Association.

ARTIFICIAL GEMS.

THE production of artificial gems has been a favorite pursuit of many intelligent chemists and physicists since the most ancient times. The great material value of precious stones was always an incentive to the imitation of these, but practice remained far behind theory, and few positive results were obtained. Now, as reported in the Paris papers, certain French chemists have at last succeeded in discovering a new and more practical method of manufacturing artificial gems, particularly rubies. We are familiar with the epoch-making analyses and experiments of Moissan, and his artificial diamonds; but the tiny crystals produced in the electric furnace, from coal, are so small that they are of no practical use, and jewelers as well as goldsmiths agree that their actual value is null. In addition to this, the cost of production is so great that the experiment is seldom made, and when undertaken is more for scientific than for practical purposes. The case is different with artificial rubies, and the "Geneva rubies," so called, have attained general popularity. The makers have endeavored to keep the process of their manufacture a strict secret, but not with entire success. We are told that in the "machine" constructed by a Parisian chemist for manufacturing artificial rubies, there is a blow pipe, similar to a glass-blower's pipe, and a heating pipe. Into the latter are sifted finely pulverized alumina and chromium oxides, alternately, to form a deposit in strata, and in the shape of a pointed sugar-loaf. This formation makes gradual heating possible, the mass takes a spherical form, and on hardening, the crystalline character of the ruby appears. Great care is taken to let it cool slowly, in order that the formation of the crystals shall be regular and the stones clear. With this quite simple apparatus three or four rubies are made at a time, and they can be distinguished from natural, mechanically-cut rubies only by skilled experts. They often weigh from 13 to 16 carats, and have a cross section of 6 or 7 millimeters. The greatest care is needed to prevent the formation of bubbles.—Edelmetall Industrie.

[Continued from SUPPLEMENT No. 1583, page 25362.]

RESERVOIR, FOUNTAIN, AND STYLOGRAPHIC PENS.—V.*

By JAMES P. MAGINNIS, A.M.Inst.C.E., M.Inst.Mech.E.

FOUNTAIN PENS.

I CANNOT do better than begin here by quoting the words of Mr. De la Rue, who says: "As probably everybody knows, a fountain pen is a pen the holder of which contains a supply of ink which is made to flow to the nib by a device called the 'feed.'" It is the feed which is in great part responsible for the proper writing of the pen. When a filled pen is held point downward, the ink it contains is acted on by a variety of forces, among which may be reckoned gravity, inertia, capillary attraction, air pressure, friction, and the viscosity of the liquid as well as several minor forces. If the pen is properly made, these forces are in a state of equilibrium, and the ink does not run out of the reservoir. As soon, however, as the point touches a surface it is capable of wetting, the action of the capillary attraction is altered, with the result that the ink is enabled to flow from the reservoir, and that the pen writes. A fountain pen, to be perfect, should fulfill certain requirements. It should be of convenient form and size, and as light as possible. Its ink-carrying capacity should be as large as is consistent with its portability. It should not be too ready to empty itself, except when required to do so, and then only at a rate not exceeding the requirements of the writer. It should be prompt in delivering the ink the instant the nib touches the paper. It should have as few parts as possible, and these free from complication or liability to injury from careless handling. The possessor of such a pen, provided it be fitted with a gold nib suited to his style of writing, need not ask for a better. Many of those I shall refer to are full of complications, and of what are now proved to be unnecessary parts, while others appear to be of the very essence of simplicity, perhaps too much so. Of fountain pens perhaps one may say, as of other things, the fittest survives, and in those of to-day will be found the adoption of the result of the experience of former days. *Experientia docet.* It is another case in which the principle of "trial and error" helps materially to assist one in arriving at the best means to an end.

Frederick Bartholomew Fölsch obtained a patent in 1809 (3235), for "Several Improvements calculated to promote Facility in Writing," wherein he describes his invention shown in Fig. 105 as being divided into three parts, namely, the box, *B*, the tube, *T*, and the socket, *S*, all of which may be joined together by screws, or socket joints. The socket, the lower part of which is made in the shape of a common pen with a slit up the nib, is hollow, and has a hole in the front to admit air, and to adjust the quantity of ink it will bear. At the lower end of the tube, *T*, is a small pipe, *P*, for the ink to pass through to the socket. The box, *B*, contains a small rod, *R*, one end of which passes through a hole in its bottom, with a valve, *V*, covered with leather fastened to it, while the other end screws into a knob, *K*. A spiral spring, *S*, keeps the valve or plate close to the bottom of the box. Or, as shown in Fig. 106, the spring may be done away with by screwing the knob at once onto the tube, and making an airhole within the screw part of it, which will admit air into the tube by unscrewing the knob a little.

Again referring to the specification of Joseph Bramah, of September, 1809 (3260), we find that he there claims a patent for "A New Method of Making Pens, Pen-making Machines, Penholders, and Fountain Pens." In this specification, he describes how the handle of the penholder may be a hollow tube of silver or of any other metal or material proper for the purpose, tapering at the lower end to fit the socket, and with a small perforation a little distance from the point, the upper end being made airtight with a cork, cap, or otherwise. The tube is made so thin as to be readily compressed out of circular shape by a small pressure between the fingers and thumb which hold the pen. If a larger supply of ink be required than such a tube will hold at one time, a bulb may be added at the upper extremity or in any other part. Instead of a stopper, a piston may be slid down the interior of the tube to force down the ink to the pen, by the hand or screw, etc. Any common pen, Bramah says, may be converted into a fountain pen, by scraping that part of the quill where the thumb rests until it is so thin that the pressure of the end of the thumb will be a little more than the necessary force for holding the pen, and by inserting into the open end of the pen above the mouth a small cork, or any substance calculated to operate as a stopper, having previously made in the part of this stopper which falls in contact with the back of the pen, above the slit, a small groove not larger in dimensions than the smallest pinhole, longitudinally along the surface thereof. Here we have a description of a very up-to-date fountain pen, with its feed bar very much as at present used.

In July, 1819, appeared the next patent (4389), granted to John Scheffer for a machine or instrument for writing, which he calls the "Penographic, or Writing Instrument." In this invention the ink is caused to flow to the nib by pressure exerted upon a lever. Generally speaking, the instrument consists of an external metal case, having at the top a stopper of cork, and near the bottom end a cock tube. Inside the case is an elastic tube formed of part of a goose quill, covered with sheep's gut. A valve or plug passing through the cock tube is acted upon by a lever. The nib is described as being formed of part of the barrel of a quill or other suitable material.

In December, 1819, James Henry Lewis patented "an improvement on pens" (4426) which he calls, "Calligraphic Fountain Pens." This pen was made partly of a barrel of a quill and partly of metal tubes. Ink was caused to flow to the nib by pressure of the finger and thumb, and its flow was held in check by the insertion of a piece of sponge within the lower end of the barrel. The inventor also proposed making the barrel in duplicate, so as to hold different colored inks, means being provided to supply the nib with either ink at will.

In July, 1827, George Poulton described "an instrument, machine, or apparatus for writing" (5517), which he calls a "Self-supplying Pen," composed of a "tube or reservoir, pen and shield," that may be attached or separated at pleasure. The reservoir into which the ink is introduced is screwed onto the pen. There is a weight within it which presses the ink into the pen by its own gravity when in use. The pen is made of steel, cased with metal, to prevent any corrosion, and is partly like a tube, with a valve within it to regulate the flow of ink.

John Joseph Parker obtained a patent (6288) in 1832, "for certain improvements in fountain pens," and he describes his pen (shown in Fig. 107) as having a piston, *P*, and rod in the barrel, *B*, with which to force ink to the nib as required, to which it is delivered through a small bell-mouthed tube, *T*. To fill the barrel, he says, dip the end of the penholder into ink, and raise the piston by turning the outer case. In this specification we have the first mention of a so-called self-filling pen. A wire, *W*, attached to the inside of the cap, *K*, enters the ink-delivering passage, and prevents the outflow of ink when the cap is placed over the nib.

A telescopic penholder is shown in Fig. 108 (7535, John Edwards, 1838), formed of two tubes, *A* and *B*, each having an air-hole, the upper tube, *A* sliding in the lower or ink reservoir *B*, one end of the upper tube being packed to form an air-tight piston, *P*. An air-hole in the ink reservoir is covered by a sliding collar, *C*, on the outside, packed with leather, cork, or other suitable material to render it air-tight. The upper tube, *A*, when withdrawn, may be held in that position by turning it round two or three times, when it becomes screwed into the lower tube. A tapering plug,

Fig. 105.

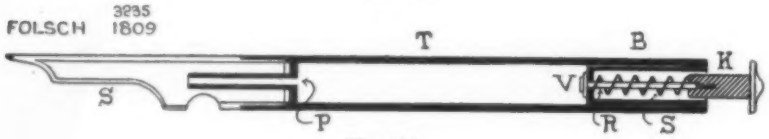


Fig. 106.

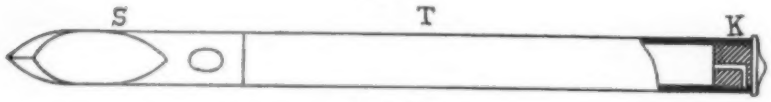


Fig. 107.

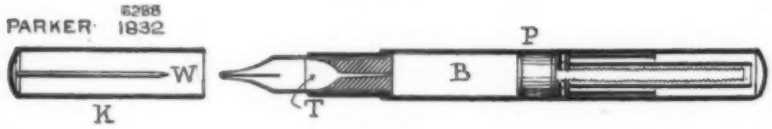


Fig. 108.

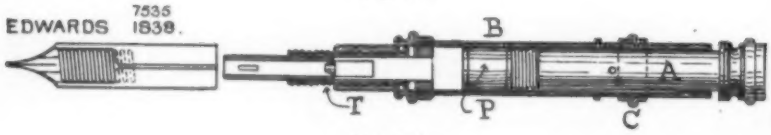


Fig. 109.

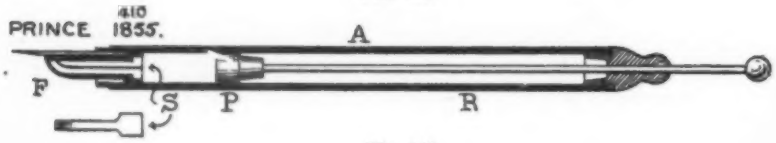


Fig. 110.

Fig. 111.

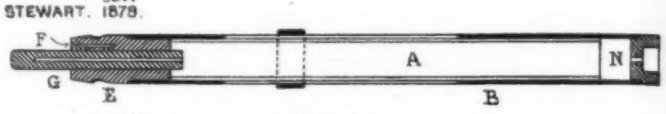


Fig. 112.

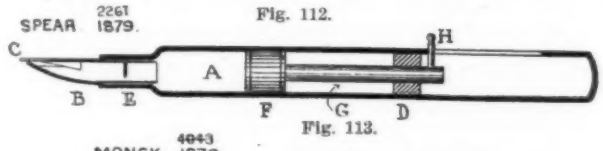


Fig. 113.

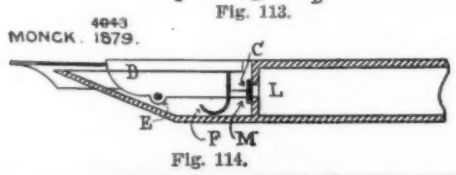


Fig. 114.

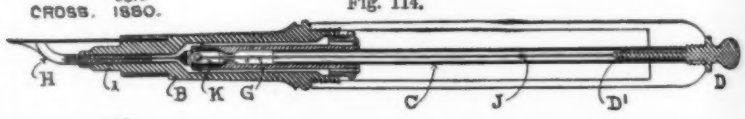


Fig. 115.

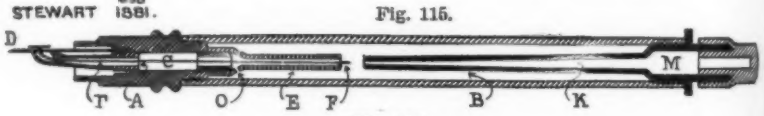
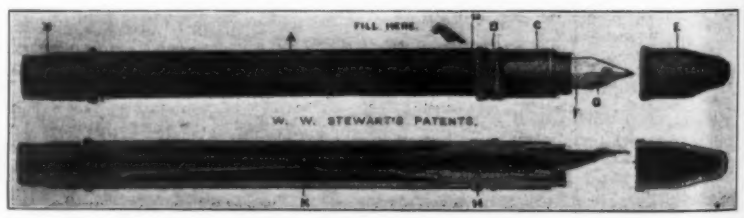


Fig. 116.



Henry Columbus Hurry patented an improvement (107, 1852) whereby the ink was prevented from leaking out of the penholder when out of use, by the employment of a valve which was capable of closing the ink passage, and rendering the reservoir perfectly air-tight.

In 1852, W. R. Bertolacci describes (537) an "improved pneumatic ink and penholder." It consists, he states, of a tube or reservoir in which is inserted a tube of vulcanized India-rubber, if anything larger than the reservoir. The nib is inserted between these two tubes. The ink is made to flow underneath the nib. A pressure knob passing through the reservoir presses against the India-rubber tube. In the upper part of the tube or reservoir is a piston, which is moved up and down by a tube turning round with a screw, moving in the screw of the piston rod. To fill the reservoir with ink place the nib end in a vessel containing ink, and raise the piston by the screw. Methods of delivering ink to the nib are described, by means of elastic bulbs, on which pressure may be exerted as required. A cap is also referred to, which when screwed on the point of the pen renders it safe to carry in the pocket.

In 1855 a patent (410) was obtained by Newell A. Prince for an improvement in the ink feed. This inventor makes his fountain pen, as shown in Fig. 109,

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principally of hard vulcanized rubber. In the lower end of the reservoir, *A*, a feed tube is fitted, bored through its middle with a hole which is largest at its upper end. Near the bottom of the feeder an aperture is made, perpendicular to the bore thereof, from which the ink issues to feed the nib. Within is a flat spring, *S*, whose upper end is wide enough to be wedged fast into the feeder, the rest being narrower than the diameter of the bore, so that it may vibrate freely by the action of the nib in writing. The lower end of the spring is bent nearly at right angles, to allow it to project through the aperture and come into contact with the under part of the nib. As the nib in writing is lifted from the orifice in the feeding tube, the end of the spring follows it, so that the constant motion of the nib when in use aids in supplying it with ink. The piston, *P*, and rod, *R*, furnish a ready means of filling the reservoir with ink.

Walter Moseley's specification of 1859 (2678), describes a fountain pen (Fig. 110) in which the ink reservoir, *R*, is constructed of soft India rubber, to fill which with ink, a screw cap, *K*, is turned a few times, whereby the India rubber becomes twisted and forces the air out. On turning the screw the reverse way, and at the same time dipping the end of the penholder in ink, the India rubber resumes its tubular form and draws up a supply of ink. To regulate the flow of ink to the nib, the part, *D*, may be adjusted in the plug, *C*. Pressure on the flexible tube (where it is exposed through an opening in the metal casing) will force ink downward to the nib. The inventor sometimes provides a small knob or button for this purpose, as shown in the drawing, instead of leaving the India rubber tube exposed.

Fig. 117.

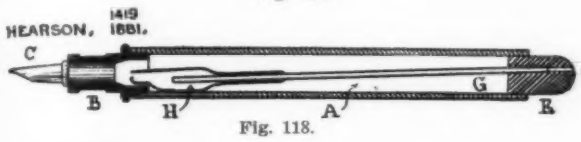


Fig. 118.

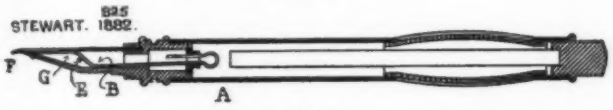


Fig. 119.

Fig. 120.

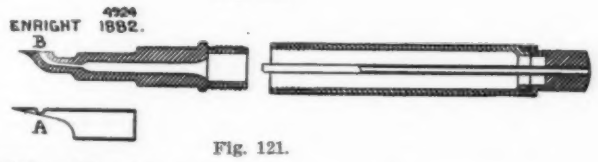


Fig. 121.

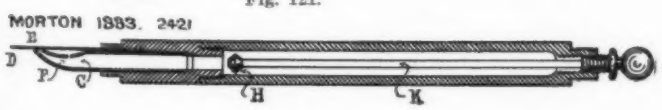


Fig. 122.

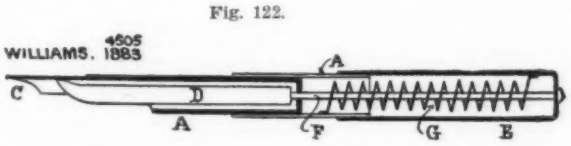


Fig. 123.

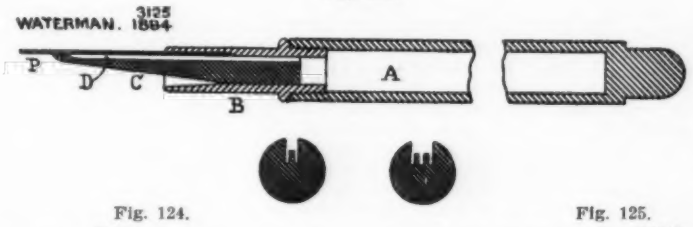
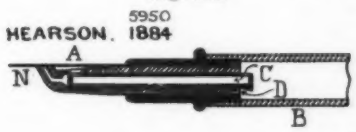


Fig. 124.

Fig. 125.



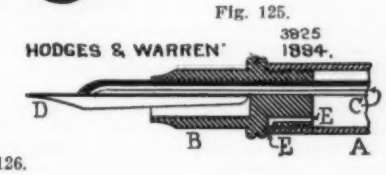


Fig. 126.

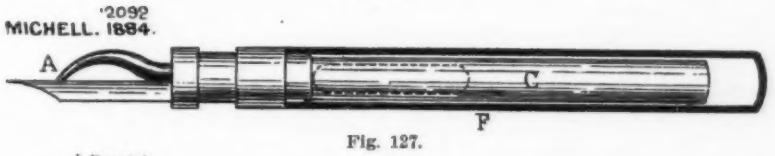
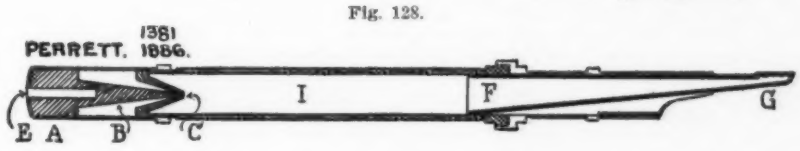


Fig. 127.

Fig. 128.



In the invention of John Darling, in 1867 (288), the tubular part of the pen is, as the inventor states, completely filled (i. e., from end to end) with an elastic tube, from which a distributing tube terminates under the nib. A flat wire, provided with two thumb-plates, extends practically the entire length of the elastic tube, and openings are provided in the tubular part or casing of the pen through which the thumb-plates may be operated. Pressure on the thumb-plates will flatten the elastic ink reservoir, and if the point of the tube be dipped into ink, the expansion of the tube will be followed by a supply of ink. Or ink may be forced onto the nib by a slight pressure on the lower plate while writing.

Under the heading, "Fountain Pens," provisional protection was granted to John Butcher (1964), in July, 1870. The stem, he says, is an elastic tube closed at its upper end, and open at the lower end next the nib. To charge the tube the air is expelled by twisting, drawing, or squeezing it; this being done, its resilience draws in the ink. The elasticity of the tube allows ink to flow to the nib for some time, and the supply is kept up by twisting or squeezing the tube. In combination with the tube are either two removable nibs, both of which, or only the under or writing one, are slit; or a piece of fibrous or porous material, to prevent too rapid a flow of ink to the nib.

Messrs. Rheinberg obtained provisional protection in November, 1870, (3002) for "Improvements in Penholders." No drawings are published with the specification, but we are told that the handle is tubular, and forms, with a flexible tube at its lower end, an ink reservoir. At one side of the handle there is a stud, on which "the finger presses in writing." This stud abuts on the flexible part, presses it inward, and causes ink to flow out through a small hole in the bottom thereof into the pen. To charge the reservoir, the hole is immersed in ink, and a piston which is contained in the hollow handle is drawn up.

In Stewart's patent of September, 1878 (3644), Fig. 111, an elastic tube, *A*, is protected by a barrel, *B*, of metal, or hard vulcanite rendered somewhat flexible by suitable perforations. The head, *E*, or, as it is usually called, the point section, is fixed in the barrel, and a slit, *F*, is provided in it for the reception of the nib, and a central duct, *G*, closed at its extreme end, through which ink is supplied to the under side of the nib. The pen may be filled by suction through the air opening at *N*. To prevent ink escaping when the pen is carried in the pocket, a cap or sleeve is provided, which may be turned one-half a revolution so as to cover the orifice supplying ink to the nib.

In November, 1878 (4714) S. Fox obtained provisional protection for a fountain pen. The penholder is tubular, and has attached to its upper end a length of flexible tubing of small diameter, the other end of which is connected to an ink bottle. To assist the flow of ink, the ink bottle is raised somewhat above the level of the writing table, preferably upon a stand the height of which might be adjusted to the most suitable elevation. The penholder terminates in a very small tube, fixed immediately under and against the nib, and being provided with a regulator whereby the flow of ink may be regulated. When not in actual use the pen is inserted in the ink bottle. This inventor further suggests that the ink bottle may be made to hook into the buttonhole, or be otherwise attached to the person.

The drawing, Fig. 112, shows a section of a pen-holder patented in June, 1879 (2261), by R. Spear. It consists of a holder and ink reservoir, *A*, to which the feeder of ink, *B*, to the nib, *C*, is joined. When the nib, *C*, is in position, the feeder, *B*, extends nearly to its point and almost touches its under side. A piston, *F*, with its rod, *G*, fits inside the reservoir, *A*, and is operated by the pin, *H*, slightly projecting through the holder, *A*, in which a slot is provided for its accommodation. The piston rod, *F*, is guided by a diaphragm, *D*, through which it passes. This diaphragm divides the ink reservoir from the upper half of the holder. To fill the reservoir the point of the holder is immersed in ink, and the piston drawn slowly upward, when the ink is drawn into the holder.

F. W. Monck, in December, 1879 (4943), patented the method of regulating the supply of ink from the reservoir to the nib, shown in Fig. 113. The main reservoir is divided from the point by a wall or diaphragm, in which is a small opening, as shown at *L*. The pen-carrier, *D*, is pivoted at *E*, to a rod, *M*, carrying a valve, *C*, fitting the opening, *L*. The rocking action of the pen in writing opens the valve and allows ink to flow to the nib, while the spring, *F*, tends to keep the valve closed.

In July, 1880 (2879), Mr. A. T. Cross patented a pen, as he describes it, with a reservoir to which air is admitted at the lower end, and to be used with ordinary nibs. A section of the pen is here shown in Fig. 114, and compared with the fountain pen of to-day it is a complicated instrument, full of details which experience has proved to be superfluous. It has some resemblance to the stylographic pen, and the inventor claims protection in the same specification for a stylographic pen having a somewhat similar interior arrangement of parts. In a fountain pen, the air tube, *C*, has at its lower end an adjustable sliding guide, *G*, to which a tube-clearing spindle, *I*, is rigidly fixed. The spindle, *I*, passes through a small ink-delivering tube, *H*, which is frictionally held in the bore of the point section, *B*. A fine connecting wire, *J*, is attached to the guide, *D*[1], which extends from the vent plug, *D*, into an air tube, and passes through a contracted part of the guide, *G*, to which it is loosely secured, by its enlarged head being held in the chamber, *K*.

Another instance of a self-filling pen is referred to in the provisional patent of A. Tust, November, 1880 (4624), in which the ink reservoir is of the usual tubular form fitted with a piston and piston rod, which former also acts as a pressure valve to force the ink to the pen. The holder in which the nib is fixed is so arranged that it forms a valve to prevent too ready a flow of ink. Pressure upon the nib, as in writing, opens this valve.

Stewart's patent of February, 1881 (698), consists of the usual ink reservoir, *B* (Fig. 115) within which is the air tube, *K*, enlarged at its upper end, *M*, and extending about two-thirds of the length of the ink reservoir. The point section is extended upward, as at *E*, and openings, *O*, are provided, through which the ink finds its way downward into the ink chamber, *C*, and thence by means of a short tube, *A*, to the nib, *D*. A capillary wire, *F*, is fitted to the top of *E*, and passes downward to the nib, *D*, at the back of which it is formed into a coil, shown at *T*, to prevent the nib from becoming too dry when not in use. This wire forms a conductor for the air, entering in the form of minute bubbles, which gradually pass upward along its surface into the ink chamber, *C*, where they collect and form an elastic cushion between the ink contained in *C*, and that in the reservoir, *B*. This pen (also shown in Fig. 12) was introduced by Messrs. Mabie, Todd & Bard, of New York, as the "Calligraphic" fountain pen, and Mr. Robinson was the first to bring it to England.

Jackson's prov. patent 1881 (907) provides a flexible tubular reservoir of India rubber, inclosed in an outer holder or casing. One end is attached to the lower end of the holder in which a passage is formed to carry the ink to the nib. The other or upper end terminates in a plug, turning which twists the flexible reservoir, and drives the contents, whether this be ink or air, outward. To fill the reservoir the tube is untwisted while the point is inserted in ink.

In T. R. Hearson's patent of March, 1881 (1419), Fig. 117, the reservoir, *A*, is fitted at its upper end with a plug, *E*, into which the air tube, *G*, is fixed. At the other end is fitted the nib holding piece, *B*, which is removable for filling the reservoir. The air tube, *G*, is inclined as shown, and is surrounded by an ink chamber, *H*, which serves to form a trap to prevent ink running into the air tube. The nib, *C*, is of the barrel type, and is surrounded by a thin India rubber covering through which the points of the nib project slightly. The rear end of the nib is open to the ink reservoir, and the nib is kept fully charged with ink. As soon as pressure is brought to bear on the nib in writing, the points separate, and an ink passage is established which keeps the nib supplied. This immediately closes when pressure is relaxed.

In Poznanski's pen of 1881 (2754) at the top of the ink reservoir is fitted a soft rubber tube, one end of which is closed. This tube is supported by a sleeve,

and a small plunger or piston is placed against it so that pressure with the finger on this plunger compresses the rubber tube, and thus forces ink through a small opening immediately under the nib. The lower part of the reservoir is fitted with a plug terminating in a tubular feeder, with a small opening, through which passes a rod, said to be of some non-hygroscopic material to assist the flow of ink.

The ink reservoir of Sparling's pen of 1881 (3887) is closed at its lower end by a plug, perforated by a single hole, through which the ink passes to the nib. Into the other end a rod slides, packed so as to form an airtight piston by means of which ink may be drawn into the reservoir, or forced down to the nib.

In W. W. Stewart's patent pen of February, 1882 (825), a section of which is shown in Fig. 118, a permeable strand, *B*, of cord or straw, or other suitable substance, is arranged to conduct the ink from the reservoir, *A*, to the nib, *F*. It is held in close contact with the nib by a pin, *E*. An ink tube or gutter, *G*, is formed under the nib. The interior of the reservoir is described as being glazed in order to attract globules of air, or glazed parts are introduced to effect the same purpose.

Cohn's pen of 1882 (840) was only provisionally protected, but shows the desire to produce a self-filling pen. The reservoir consists of an elastic tube closed at the top and communicating at the bottom with a small pipe, through which ink passes to the nib. To drive ink to the nib, and also to allow the tube to be filled by suction, the tube is compressed by means of a longitudinal block fitted in a slot in the penholder, and bearing against the flexible ink reservoir. In another form, a pin projecting through the end of the penholder might be twisted, and with it the flexible tube.

Messrs. Hughes and Carwardine, in August, 1882 (4152), patented the method here illustrated in Fig. 119, of conducting ink to the nib by means of an India rubber bag, *B*, through which the point, *A*, of the nib passes, as shown. Pressure upon the nib in writing causes the points to spread apart, thus expanding the opening in the rubber bag and allowing ink to exude. The rear end of the rubber bag is carried through the cylindrical part of the barrel of the pen, and turned thereover, as may be seen. In order to prevent ink from escaping at the point of the nib, the nib and bag are dipped in India rubber solution.

In Fig. 120 is shown the point section of a pen patented in October, 1882 (4924), by R. Enright. It will be seen that the ink passage takes an upward bend, and terminates immediately under the nib. The nib, illustrated separately underneath, is of barrel form, and has a distinct depression, *A*, which, when the nib is placed in position, completely closes the opening, *B*, of the ink passage in the manner of a valve. This valve would naturally open by pressure on the point of the nib in writing.

Robert Shaw, in October, 1883 (2411), used a tubular holder of metal or other material, entirely closed except at the lower end where the nib is entered, and at this opening, or a short distance therefrom, a cross or bridge piece is fitted in as support for the ink. Through the opening which admits the nib a number of very fine wires, hairs, or other minute fibers are passed, soldered, or otherwise fixed on the top of the holder, while their opposite ends lie against the under side of the nib, terminating within a short distance of its points. There is a small air-hole in the lower end of the holder. This, I think, is the first mention of air being admitted at the lower end.

In 1863 (2227) Joseph Maggs describes his invention of a fountain pen, in which the holder is hollow and contains a flexible tube of India rubber, closed at its upper end, and connected with a short spiral tube which forms its mouth, at the other end. The spiral tube extends to near the point of the nib, and a slight pressure on the tube by the thumb or finger in the act of writing insures the requisite down-flow of ink. It is presumed (as there are no drawings published with the specification, which was only a provisional one), that there was an opening in the side of the metal holder to permit of the finger pressing upon the flexible reservoir. This is evidently a pen of the self-filling type.

In the patent of J. Morton, of July, 1883 (2421), shown in Fig. 121, a valve, *H*, is carried on a rod, *K*, which, at its upper end, is screwed into the end of the ink reservoir. When this rod is closely screwed down the valve completely closes the ink passage, and thus prevents risk of leakage when the pen is lying flat, or carried in the pocket, point downward. Ink is conveyed to the nib, *D*, when required, through the feed tube, *C*, to the vent, *E*. A small opening is also provided at *F*, to admit air.

Referring to Osborn's pen of 1882 (5558) a long pin passes through the ink reservoir, carrying two small valves, which regulate the supply of ink to the nib. These valves are normally held closed by springs. The nib is carried on a tube connected to the ink feeder. Pressure on the nib in writing opens both valves simultaneously, one admitting air, and the other allowing the flow of ink to the nib.

In Bertram's pen of 1883 (3268), the air tube (solid at its lower end) is fixed to the cap which screws on the end of the ink reservoir. The solid end of the air tube fits into, and closes the ink passage, through which the ink finds its way to the nib. When the cap is partially unscrewed air is permitted to enter the tube by an opening provided, and thence to the ink reservoir. The solid end is also thus raised from its seat, and ink is permitted to flow to the nib.

In Vale's pen of 1883 (4401) an elastic ink reservoir is contained within a protecting covering. The lower end of the reservoir is fixed to a mount, in which the nib is placed, and through this mount is a passage leading the ink to the under-side of the nib. The other end of the flexible reservoir is attached to a mount, controlled by a screwed cap. By turning the cap the reservoir is twisted, and ink is forced downward. By untwisting the reservoir the ink is withdrawn from the nib. Provision is made whereby it is impossible to twist the flexible tube to destruction.

In Mr. J. F. Williams's invention (4505) of September, 1883, the reservoir consists of a tongue or tube, *D*, Fig. 122, capable of holding a considerable quantity of ink, and of delivering it at the underside of the nib, *C*, fitted in the usual manner into the tubular holder, *A*. The tongue, *D*, is carried on a rod, *F*. The upper end of this rod is fixed to a cap, *E*, which slides telescopically upon the holder, *A*, and which may be pressed forward against the spring, *G*. To fill the tongue, the cap, *E*, is compressed, and the tongue on being dipped into ink becomes filled, and is then withdrawn to the position shown, by the action of the spring. This cannot be called a portable fountain pen. The inventor evidently intended to save frequent dipping into the ink-pot.

Fig. 123 shows the feed bar of L. E. Waterman, in 1884 (3125). The ink reservoir, *A*, carries a point section, *B*, at one end, and the feed piece, *C*, fits tightly into the point section. An ink duct, *D*, is formed along the feed, and consists of longitudinal fissures or saw cuts. The nib, *P*, is secured between the feed and the point section, and ink is fed to the nib by gravity and capillarity, air being drawn into the reservoir along the fissures of the ink duct. Below are transverse sections of the feed bar showing two arrangements of ducts. It will be seen that the main groove contains in one case two minor grooves, and in the other three, very fine saw cut grooves. These commence at the back end, and extend nearly to the point as shown in the longitudinal section.

Mr. T. A. Hearson's pen of April, 1884, (5950), is illustrated in Fig. 124. In this drawing is shown a form of feed having two distinct passages. The upper one formed by the tube, *C*, conducts the air from the aperture, *A*, into the ink reservoir, *B*, while the other passage, *D*, is formed by the tube, *C*, being flattened on its under side permitting the downward flow of ink to the nib, *N*. An arrangement, not shown, is described, whereby ink may be prevented from passing along the channel, *D*, so that the pen may be safely carried in the pocket.

The feed arrangement of Hodges and Warren, of March, 1884 (3825), is shown in Fig. 125. In this pen a long tube, *C*, slit up its entire length, extends nearly to the top of the ink reservoir, *A*. The end of this tube is bent over at its lower end, and delivers the ink to the back of the nib, *D*, at the slit or pierce. An air hole, *E*, is provided to facilitate the escape of air while screwing the point section, *B*, into place in the reservoir.

Fig. 126 shows F. B. Michell's patent of September, 1884 (12092). Here the holder, *F*, contains a flexible rubber bag, *C*, from which the ink is expelled while writing by the pressure of the fingers, the holder, *F*, being slotted for this purpose. Ink is fed to the nib by means of the tube, *A*, and in the drawing it is shown as being delivered on the top of the nib. I possess a similar pen in which the ink feed is underneath the nib.

In Fig. 127, Kollisch's patent of 1884 (16800), the ink reservoir, *A*, is formed of a rubber tube from which the ink is ejected by twisting. The reservoir, *A*, is attached to the part, *C*, which carries a toothed ring *D*, in gear with the outer casing, *G*, and also with the ring, *F*, attached to the cap, *B*. On turning the cap, and with it *D* and *C*, the reservoir, *A*, becomes twisted. The teeth on *G* prevent *A* from returning unless the cap be raised sufficiently to disengage the teeth which are kept in gear by means of the spring, *E*. As in other similar arrangements the reservoir is filled by allowing it to become untwisted while the point is immersed in ink.

In Brown's patent of 1886 (9132), the ink is distributed over the upper surface of the nib, by the feed bar, which is suitably formed for the purpose, and grooved to regulate the flow of ink. The air inlet consists of a tube, bent round at its inner end, so that the opening may face the plug through which the tube passes. A diaphragm is so pivoted as to be capable of entirely cutting off the ink from the nib.

In Bartram's pen of 1885 (10070), the ink is contained in the holder in the usual manner, and flows to the nib along a groove in the ink conductor. Entering this groove it is drawn downward as the nib is moved in writing. An enlargement is formed in the conductor, having notches or serrations to permit of a free passage of air through the openings, in a diaphragm, into which latter the ink conductor, or feed, is screwed. When it is desired to prevent ink from flowing, the conductor is screwed outward till the opening is covered, in which condition the pen may be carried in the pocket. A rubber ring holds the ink conductor steady.

Fig. 128 shows a section of Perrett's pen of 1886 (1381). The tubular reservoir, *I*, is formed with an air-valve, *C*, and an ink conducting tube, *F*. The valve, as may be seen, is formed by a tapering point, *B*, attached to the cap, *A*, and by means of the latter, which has a screw connection with the reservoir, *I*, it may be raised or lowered, as desired, by turning the cap. Air is admitted at *E*, and when the valve is open, finds its way into the ink reservoir. The ink conducting tube, *F*, is of tapering form, and has a groove along which the ink flows to the spoon-shaped extremity, *G*. This is another instance in which air is admitted at the top of the fountain pen.

(To be continued.)

[Continued from SUPPLEMENT No. 1582, page 25315.]

VALUABLE ALLOYS.—IV.

SPECULUM METAL.

ALLOYS consisting of 2 parts of copper and 1 of tin can be very brilliantly polished, and will serve for mirrors. The mirrors of the most ancient people were pieces of the mineral called iron pyrites, smoothly polished. Metallic mirrors were first used by the civilized nations of the East, and were made partly of copper alone and partly from special alloys; only the wealthy had mirrors made from the precious metals. The alloy best suited for this purpose is the above-mentioned compound of copper and tin; but at the present time it is only used in the construction of mirrors for optical instruments, especially large telescopes, and even here is being gradually displaced by glass.

Good speculum metal should have a very fine-grained fracture, should be white, and very hard, the highest degree of polish depending upon these qualities. A composition to meet these requirements must contain at least 35 to 36 per cent of copper. Attempts have frequently been made to increase the hardness of speculum metal by additions of nickel, antimony, and arsenic. With the exception of nickel, these substances have the effect of causing the metal to easily lose its high luster, any considerable quantity of arsenic in particular having this effect.

The real speculum metal seems to be a combination of the formula Cu,Sn, composed of copper 68.21 per cent, tin 31.7. An alloy of this nature is sometimes separated from ordnance bronze by incorrect treatment, causing the so-called tin-spots; but this has not the pure white color which distinguishes the speculum metal containing 31.5 of tin. By increasing the percentage of copper the color gradually shades into yellow; with a larger amount of tin into blue. It is dangerous to increase the tin too much, as this changes the other properties of the alloy, and it becomes too brittle to be worked. We give below a table showing different compositions of speculum metal. The standard alloy, already mentioned, is undoubtedly the best.

	Copper.	Tin.	Zinc.	Arsenic.	Silver.
Standard alloy..	68.21	31.7	—	—	—
Otto's alloy.....	68.5	31.5	—	—	—
Richardson alloy.	65.3	30.0	0.7	2	2
Little's alloy....	65.0	30.8	2.2	1.9	—
Sollit's alloy....	64.6	31.3	4.1	Nickel	—
Chinese speculum metal....	80.83	—	—	8.5	Antim'y
Old Roman.....	63.39				

PHOSPHOR BRONZE.

The variety of bronze known by this name is distinguished by such excellent qualities, that it attracted to itself the attention of all bronze workers from the time of its discovery. In the strict sense of the word it is not to be considered as an alloy containing a certain amount of copper, but rather as a bronze subjected to a peculiar treatment with the use of compounds of phosphorus. Many good phosphor bronzes contain but a very small quantity of phosphorus, which exerts no essential influence upon the character of the alloy. In these cases the phosphorus acted during the preparation of the alloy.

It has previously been remarked that bronze not infrequently contains a considerable quantity of cuprous oxide in solution, which is formed by direct oxidation of the copper during fusion, and that this admixture is highly detrimental to the strength of the alloy. If now the melted bronze be treated with a substance capable of exerting a powerful reducing action, as, for instance, phosphorus, a complete reduction of the cuprous oxide will take place, and the bronze will acquire a surprisingly high degree of strength and power of resistance. If precisely the quantity of phosphorus necessary for the complete reduction of the oxide has been used, no phosphorus will be found in the alloy, which nevertheless must be classed as phosphor bronze. It follows from what has been said, that phosphor bronze is not a special kind of alloy, but that any bronze can be made into phosphor bronze; it is, in fact, simply a deoxidized bronze, produced under treatment with phosphorus compounds.

Although the effect of phosphorus in improving the quality of bronze has been known for more than fifty years, it is only of late that the method of preparing phosphor bronze has been perfected. It is now manufactured in many localities. Besides its action in reducing the oxides dissolved in the alloy, the phosphorus exerts another very material influence upon the properties of the bronze. The ordinary bronzes consist of mixtures in which the copper is really the only crystallized constituent, since the tin crystallizes with great difficulty. As a consequence of this dissimilarity in the nature of the two metals, the alloy is not as solid as it would be if both were crystallized. The phosphorus causes the tin to crystallize, and the result is a more homogeneous mixture of the two metals.

If enough phosphorus is added, so that its presence can be detected in the finished bronze, the latter may be considered an alloy of crystallized phosphor tin with copper. If the content of phosphorus is still more increased, a part of the copper combines with the phosphorus, and the bronze then contains, besides copper and tin, compounds of crystallized copper phosphide with phosphide of tin. The strength and tenacity of the bronze are not lessened by a larger amount

of phosphorus, and its hardness is considerably increased. Many phosphor bronzes are equal in this respect to the best steel, and some even surpass it in general properties.

The phosphorus is added to the bronze in the form of copper phosphide or phosphide of tin, the two being sometimes used together. They must be specially prepared for this purpose, and the best methods will be here given.

Copper phosphide is prepared by heating a mixture of 4 parts of superphosphate of lime, 2 parts of granulated copper, and 1 part of finely pulverized coal in a crucible at a temperature not too high. The melted copper phosphide, containing 14 per cent of phosphorus, separates on the bottom of the crucible.

Tin phosphide is prepared as follows: Place a bar of zinc in an aqueous solution of tin chloride. The tin will be separated in the form of a sponge-like mass. Collect it, and put it into a crucible, upon the bottom of which sticks of phosphorus have been placed. Press the tin tightly into the crucible, and expose to a gentle heat. Continue the heating until flames of burning phosphorus are no longer observed on the crucible. The pure tin phosphide, in the form of a coarsely crystalline mass, tin-white in color, will be found on the bottom of the crucible.

To prepare the phosphor bronze, the alloy to be treated is melted in the usual way, and small pieces of the copper phosphide and tin phosphide are added.

Phosphor bronze, properly prepared, has nearly the same melting point as that of ordinary bronze. In cooling, however, it has the peculiarity of passing directly from the liquid into the solid state, without first becoming thickly fluid. In a melted state it retains a perfectly bright surface, while ordinary bronze in this condition is always covered with a thin film of oxide.

If phosphor bronze is kept for a long time at the melting point, there is not any loss of tin, but the amount of phosphorus is slightly diminished.

The most valuable properties of phosphor bronze are its extraordinary tenacity and strength. It can be rolled, hammered, and stretched cold, and its strength is nearly double that of the best ordinary bronze. It is principally used in cases where great strength and power of resistance to outward influences are required as, for instance, in objects which are to be exposed to the action of sea water.

Phosphor bronze containing about 4 per cent of tin is excellently well adapted for sheet bronze. With not more than 5 per cent of tin, it can be used, forged, for firearms. Seven to 10 per cent of tin gives the greatest hardness, and such bronze is especially suited to the manufacture of axle bearings, cylinders for steam fire engines, cogwheels, and, in general, for parts of machines where great strength and hardness are required. Phosphor bronze, if exposed to the air, soon becomes covered with a beautiful, closely adhering patina, and is therefore well adapted to purposes of art. The amount of phosphorus added varies from 0.25 to 2.5 per cent, according to the purpose of the bronze. The composition of a number of kinds of phosphor bronze is given below:

	I.	II.	III.
Copper	90.34	90.86	94.71
Tin	8.90	8.56	4.39
Phosphorus	0.76	0.196	0.053

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Copper	85.53	. .	.....	77.85	72.50	73.50	74.50	89.50
Tin	9.85	4-15	4-15	11.00	8.00	6.00	11.00	8.00
Zinc	3.77	.	8-20	7.65	17.00	19.00	11.00	3.00
Lead	0.62	4-15	4-15	.....	.....	.....	.....	.....
Iron	traces	.	.	.	.....	.....	.....	.....
Phosphorus	0.05	0.5-3	0.25-2	.....	.....	.....	.....	.....

I. for axle bearings, II. and III. for harder and softer axle bearings, IV. to VIII. for railroad purposes, IV. especially for valves of locomotives, V. and VI. axle bearings for wagons, VII. for connecting rods, VIII. for piston rods in hydraulic presses.

SILICON BRONZE.

Silicon, similarly to phosphorus, acts as a deoxidizing agent, and the bronzes produced under its influence are very ductile and elastic, do not rust, and are very strong. On account of these qualities silicon bronze is much used for telegraph and telephone wires. The process of manufacture is similar to that of phosphor bronze; the silicon is used in the form of copper silicide. Some good silicon bronzes are as follows:

	I.	II.
Copper	97.12	97.37
Tin	1.14	1.32
Zinc	1.10	1.27
Silicon	0.05	0.07

STATUARY BRONZE.

Many of the antique statues were made of genuine bronze, which has advantages for this purpose, but has been superseded in modern times by mixtures of metals containing besides copper and tin—the constituents of real bronze—a quantity of zinc, the alloy thus formed being really an intermediate product between bronze and brass. The reason for the use of such mixtures lies partly in the comparative cheapness of their production as compared with genuine bronze, and partly in the purpose for which the metal is to be used. A thoroughly good statuary bronze must become thinly fluid in fusing, fill the molds out sharply, allow of being easily worked with the file, and must take on the beautiful green coating called patina, after being exposed to the air for a short time.

Genuine bronze, however strongly heated, does not become thin enough to fill out the molds well, and it is also difficult to obtain homogeneous castings from it. Brass alone is also too thickly fluid, and not hard enough for the required fine chiseling or chasing of the finished object.

Alloys containing zinc and tin, in addition to copper, can be prepared in such a manner that they will become very thinly fluid, and will give fine castings which can easily be worked with the file and chisel. The best proportions seem to be from 10 to 18 per cent of zinc and from 2 to 4 per cent of tin. In point of hardness, statuary bronze holds an intermediate position between genuine bronze and brass, being harder and tougher than the latter, but not so much so as the former.

Since statuary bronze is principally used for artistic purposes, much depends upon the color. This can be varied from pale yellow to orange yellow, by slightly varying the content of tin or zinc, which must, of course, still be kept between the limits given above. Too much tin makes the alloy brittle and difficult to chisel; with too much zinc, on the other hand, the warm tone of color is lost, and the bronze does not acquire a fine patina.

The best proportions for statuary bronze are very definitely known at the present day; yet it sometimes happens that large castings have not the right character. They are either defective in color, or they do not take on a fine patina, or they are difficult to chisel. These phenomena may be due to the use of impure metals—containing oxides, iron, lead, etc.—or to improper treatment of the alloy in melting. With the most careful work possible, there is a considerable loss in melting—3 per cent at the very least, and sometimes as much as 10. This is due to the large proportion of zinc, and it is evident that in consequence of it, the nature of the alloy will be different from what might be expected from the quantities of the metals used in its manufacture.

It has been remarked that slight variations in composition quickly change the color of the alloy. The following table gives a series of alloys of different colors, suitable for statuary bronze:

Copper.	Zinc.	Tin.	Color.
84.42	11.28	4.30	Reddish yellow
84.00	11.00	5.00	Orange red.
83.05	13.03	3.92	Orange red
83.00	12.00	5.00	Orange red
81.05	15.32	3.63	Orange yellow
81.00	15.00	4.00	Orange yellow
78.09	18.47	3.44	Orange yellow
73.58	23.27	3.15	Orange yellow
73.00	23.00	4.00	Pale orange
70.36	26.88	2.76	Pale yellow
70.00	27.00	3.00	Pale yellow
65.95	31.56	2.49	Pale yellow

GERMAN SILVER OR ARGENTAN.

The composition of this alloy varies considerably, but from the adjoined figures an average may be found, which will represent, approximately, the normal composition:

Copper, 50 to 66 parts.
Zinc, 19 to 31 parts.
Nickel, 13 to 18 parts.

The properties of the different kinds, such as their color, ductility, fusibility, etc., vary with the proportions of the single metals. For making spoons, forks, cups, candlesticks etc., the most suitable proportions are 50 parts of copper, 25 of zinc, and 25 of nickel. This metal has a beautiful blue white color, and does not tarnish easily.

German silver is sometimes so brittle that a spoon, if allowed to fall upon the floor, will break; this, of course, indicates faulty composition. As was said above, the composition varies so much, according to the mechanical manipulation to which the articles made from it are to be subjected, that it is impossible to give definite proportions. But the following table will show how the character of the alloy changes with the varying percentage of the metals composing it:

	Copper.	Zinc.	Nickel.	Quality.
Argentan, English	8	3.5	4	Finest quality.
Argentan, English	8	3.5	6	Very beautiful, but very refractory.
Argentan, English.	8	6.5	3	Ordinary, readily fusible.
Argentan, German	52	26 0	22	First quality.
Argentan, German	59	30 0	11	Second quality.
Argentan, German	63	31.0	6	Third quality.

The following analyses give further particulars in regard to different kinds of argentan:

	Copper.	Zinc.	Nickel.	Lead.	Iron.
For sheet (French)	50	31.3	18.7	——	——
(French)	50	30	20	——	——
(French)	58.3	25	16.7	——	——
Vienna	50	25	25	——	——
Vienna	55.6	22	22	——	——
Vienna	60	20	20	——	——
Berlin	54	28	18	——	——
Berlin	55.5	29.1	17.5	——	——
English	63.34	17.01	19.13	——	——
English	62.40	22.15	15.05	——	——
English	62.63	26.05	10.85	——	——
English	57.40	25	13	——	3
Chinese	26.3	36.8	36.8	——	——
Chinese	43.8	40.6	15.6	——	——
Chinese	45.7	36.9	17.9	——	——
Chinese	40.4	25.4	31.6	——	2.60
Castings	48.5	24.3	24.3	2.9	——
Castings	54.5	21.8	21.8	1.9	——
Castings	58.3	19.4	19.4	2.9	——
Castings	57.8	27.1	14.3	0.8	——
Castings	57	20	20	3	——

In some kinds of argentan are found varying quantities of iron, manganese, tin, and very frequently lead, added for the purpose of changing the properties of the alloy or cheapening the cost of production. But all these metals have a detrimental rather than a beneficial effect upon the general character of the alloy, and especially lessen its power of resistance to the action of dilute acids, one of its most valuable properties. Lead makes it more fusible; tin acts somewhat as in bronze, making it denser and more resonant, and enabling it to take a higher polish. With iron or manganese the alloy is whiter, but it becomes at the same time more refractory and its tendency toward brittleness is increased.

SUBSTITUTES FOR ARGENTAN.

There are many formulæ for alloys which claim to be substitutes for German silver; but no one of them has yet really taken the place of it as an article of general commerce. It will be sufficient to note these materials briefly, giving the composition of the most important.

NICKEL BRONZE.

This is prepared by fusing together very highly purified nickel (99.5 per cent) with copper, tin, and zinc. A bronze is produced containing 20 per cent of nickel, light colored and very hard.

BISMUTH BRONZE.

	I.	II.	III.	IV.
Copper	25	45	69	47
Nickel	24	32.5	10	30.9
Antimony	50	——	—	——
Bismuth	1	1	1	0.1
Tin	—	16	15	1
Zinc	—	21.5	20	21
Aluminium	—	——	1	——

I. is hard and very lustrous, suitable for lamp reflectors and axle bearings; II. is hard, resonant, and not affected by sea water, for parts of ships, pipes, telegraph wires and piano strings; III. and IV. are for cups, spoons, etc.

MANGANESE ARGENTAN.

Copper	52 to 50
Nickel	17 to 15
Zinc	5 to 10
Manganese	1 to 5
Phosphorus	.....
Copper with 15 per cent phosphorus.	3 to 5

Readily cast for objects of art.

APHTITE.

Iron	66
Nickel	23
Wolfram	4
Copper	5

ARGUZOID.

Copper	55.78
Zinc	23.198
Nickel	13.406
Tin	4.035
Lead	3.544

Silver white, almost ductile, suited for artistic purposes.

FERRO-ARGENTAN.

Copper	70.0
Nickel	20.0
Zinc	5.5
Cadmium	4.5

Resembles silver; worked like German silver.

TRANSIT OF IONS IN THE ARC.—According to the most modern view, as enunciated by J. J. Thomson in one of his recent works, the phenomenon known as the Electric Arc is explained on the assumption that the positive and negative electrodes emit respectively positively and negatively electrified corpuscles or ions, which, under the influence of electric repulsion, travel across the space occupied by the arc and bombard the electrode opposite to the one from which they have been emitted. It is further supposed that the electric current is itself conveyed by these ions, and that the high temperature of the electrodes is produced by their bombardment. About a year ago it occurred to A. A. Campbell Swinton that it should be possible to test the correctness of, at any rate, some portion of this theory by deflecting—by means of a magnet—either the positive or the negative ions into a Faraday cylinder placed with its aperture just touching the center of the arc, in a manner somewhat similar to that adopted by Ferrin for demonstrating the electric charge carried by cathode rays. The experiment was tried, but it was found that no definite results could be obtained, owing to the erratic behavior of the arc, which proved very unmanageable, and preferred to divide itself into two arcs between the carbon electrodes and the exterior of the Faraday cylinder, which was rapidly destroyed by fusion. More recently the author has made the experiment again in a somewhat modified form, and has obtained results which appear to prove conclusively that the theory, as above described, is correct, and that positively and negatively charged carriers do actually travel from the positive and negative electrodes respectively along the arc in opposite directions, and do bombard the opposite electrodes. The Faraday cylinder was placed inside one of the carbons, which was perforated in front to let the ions pass. The lamp was inclosed in a glass tube, which was slightly exhausted. The current was reversed several times, and the charge received by the Faraday cylinder varied accordingly.—A. A. Campbell Swinton, paper read before the Royal Society, November 16, 1905.

THE DOMESTIC LIFE OF ANIMALS.

By DR. TH. ZELL.

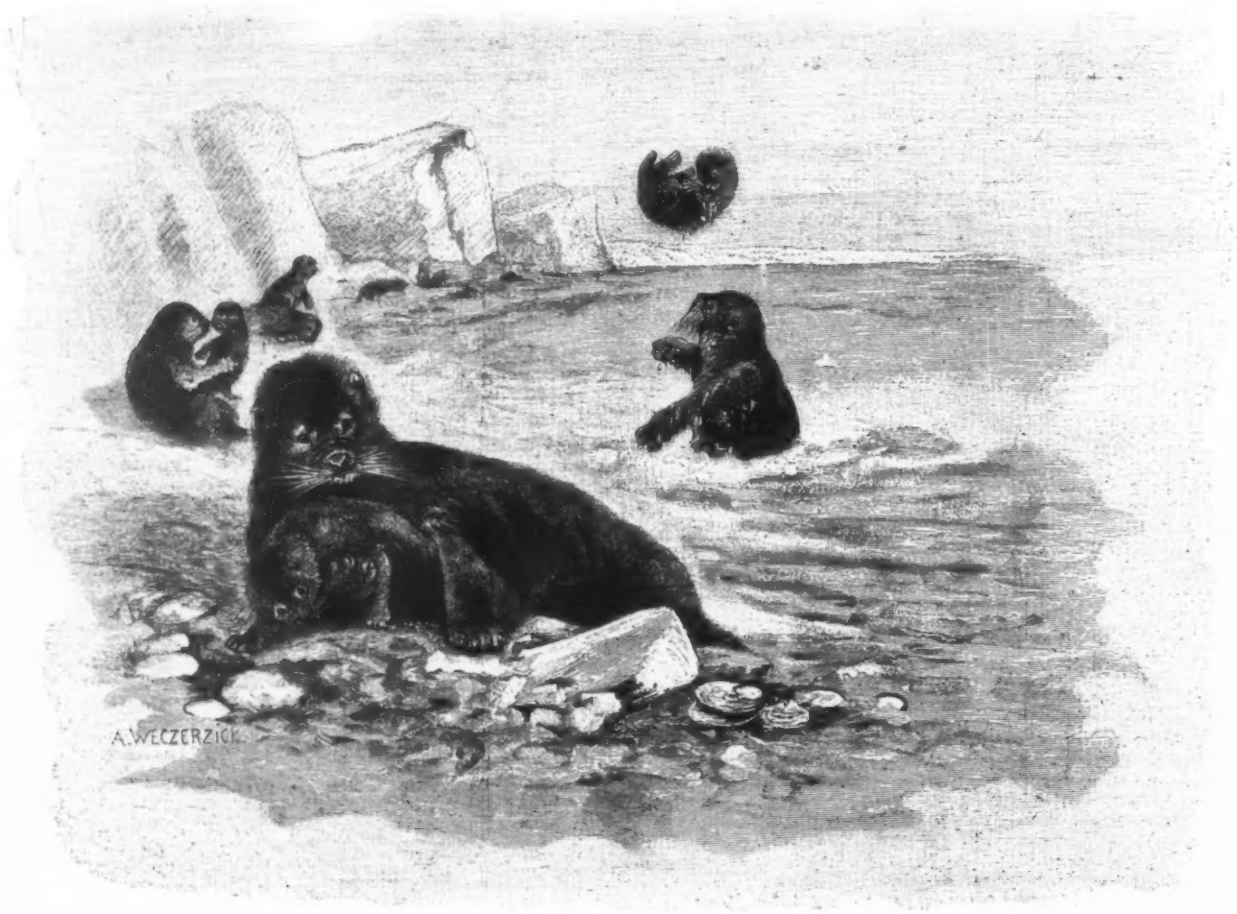
AMONG other animals, as among men, there are good fathers and bad fathers. In this respect there could not well be a greater difference than that which exists between the sea otter and the shrew. Males which take any care of their offspring are rare among mammals and this general law gives increased interest to the family life of the sea otter.

This animal, which has been hunted for its fine fur almost to extermination, inhabits the northern Pacific, and is found as far north as the Aleutian and Bering's islands. It is popularly known as the Kamchatka beaver because, like the true beaver, it lives chiefly in the water; but the beaver is a vegetarian rodent, while the other belongs to the carnivora and works great havoc among the fishes.

Another marine mammal of this region, which also is much hunted for its pelt, is the sea bear or fur seal, which furnishes most of the sealskin of commerce. The sea bear has the fin-like paws characteristic of seals and is consequently very awkward on land, but the sea otter can travel overland for many miles.

A YOUNG CUCKOO RAISED IN A WHITETHROAT'S NEST

As the sea otter has become very shy in consequence of incessant pursuit, the description of the animal which was given by Steller 150 years ago, when it was abundant, remains the best to be had and forms the basis of those given in all treatises on zoology. According to Steller, the sea otter is a very beautiful creature with a deep black glossy pelt and a joyous, merry, and extremely affectionate disposition. In Steller's day it was not uncommon to come upon a charming family group consisting of father, mother, "kashlockis" or half-grown young, and "medwedkis" or sucklings. The male caresses his consort with his fore-paws; with playful coyness she repels him and romps with her children like a loving human mother. The love of the parents for their young is so great that they will brave certain death in their defense. When their little ones are taken from them they cry like children, refuse to leave the land and soon become weak, ill, and so emaciated that they look like skeletons. They are seen with young at every season of the year. The young are born singly, on land, with open eyes and full sets of teeth. The mother carries the little one in her mouth on land, but in the water she swims on her back and clasps her offspring in her arms, like a human mother, often tossing it high in the air and catching it, throwing it into the water in order to teach it to swim, and then hugging and kissing it in a very human fashion. When pursued either on land or in the water, she refuses to abandon her baby except in the last extremity, and in this way



SEA OTTERS WITH YOUNG.

many female sea otters meet their death. Steller says: "I have robbed mothers of their young purposely, in order to study their actions. They followed me at a distance, crying and whining. When the little ones whimpered in answer I set them down, and the mothers came and carried them away. In flight they carry the sucklings in their mouths but drive the older ones before them. Once I caught a young otter and its mother asleep. The mother, awakened by my approach, tried to arouse her offspring, but as the latter preferred to sleep she seized it with her forepaws and rolled it into the water like a stone. When sea otters have escaped pursuit by taking to the water they mock the hunters in a most amusing manner, standing erect like expert human swimmers and bobbing up and down with the waves, shading their eyes with one paw and peering under it, throwing themselves on their backs and rubbing their bellies like monkeys, and playing with their little ones. A sea otter brought to bay hisses and spits like an angry cat. After a mortal blow the animal lies on its side, retracting its hind legs and covering its eyes with its forepaws, but in death it lies extended like a human corpse, with its arms folded over its breast."

A HERONS' NEST.

The eminent zoologist, Pechnel-Loesche, confirms the story of the playfulness of sea otters, saying that they frolic like dolphins and appear to take especial pleasure in leaping very high and falling back into the water with a loud splash.

In regard to family life, the shrew is the very opposite of the sea otter. According to Brehm, no other animals, with the possible exception of their cousins, the moles, are so unsocial and so continually at war with their kind as shrews. Even males and females fight together except at pairing time. In all other seasons every shrew is at war with all its kindred, not only killing, but devouring them if possible. Often two are found engaged in so desperate a duel that they can be caught with the hands. They bite and hold fast like hill dogs, rolling over and over in an indistinguishable mass. If shrews were as big as lions, they would depopulate the earth and then die of hunger.

The female makes a nest of moss, grass, leaves, and twigs, preferably in a hole in a wall or under a decayed stump, and provides it with several exits. The young, from five to ten in number, are born in early summer, naked and with eyes and ears closed. At first the mother treats them very affectionately, but soon her love cools, and they are forced to seek their own livelihood. Nor is there any paternal affection among the members of the litter. To shrews, young or old, all flesh is meat, and they do not scruple to eat the bodies of their own brothers and sisters.

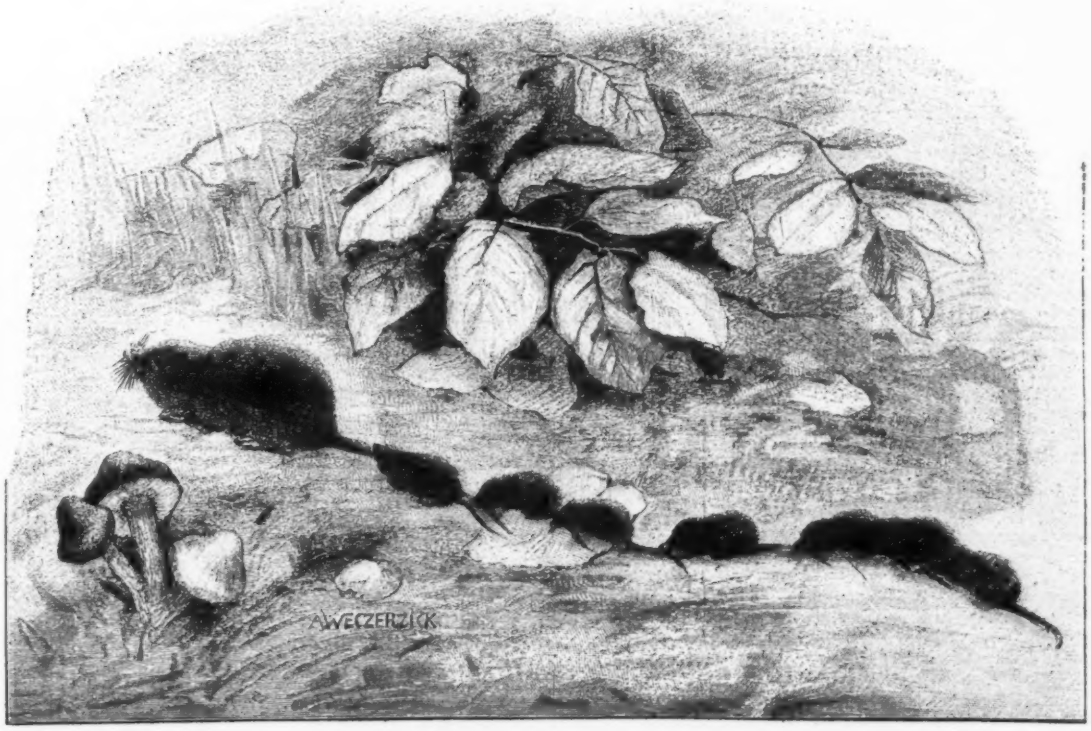
Shrews live mostly underground, in natural crevices, abandoned mouse holes and mole holes or, in default of all these, in tunnels excavated in soft soil, near the surface, with their own weak little paws and snouts. Like most of their near relatives they are thoroughly nocturnal animals, seldom emerging from the ground by day and never in bright sunshine. Strong sunlight appears to be injurious and even fatal to them—at least, it is commonly assumed that the numerous dead shrews found on roads and in ditches in summer have perished because they have been unable to find their way home in the blinding glare of the sun.

The snout of the shrew is always in motion. According to the general, though much disputed, theory, the mother leads her brood in the manner shown in the illustration. The old belief in the venomous nature of shrews is not yet extinct. By the ancient Romans the twittering cry of a shrew was regarded as an evil omen. For example, it caused the dictator Fabius Maximus to resign his office.

Herons and cuckoos differ as widely as sea otters and shrews in regard to domestic life. Nobody who is well acquainted with the crafty and mischievous heron can feel much admiration for him, but it must be conceded that he is a good father. In the middle ages herons were hunted with falcons, and attempts are being made to revive this almost forgotten sport. The heron formerly abounded in all parts of Germany, but it has been almost exterminated by the warfare waged against it because of its destruction of fish. One of the few places where the birds are still left undisturbed is the royal forest of Dubrow, near Berlin. I have often observed that the herons, though usually so shy that it is difficult to catch a glimpse of them, brave any danger in order to feed their young, flying boldly to their nests under my eyes.

Although herons have powerful beaks, they allow themselves to be plundered by smaller birds without offering any resistance. Kites carry off the young herons, and crows and magpies steal the eggs.

Nearly all male birds are exemplary fathers, while the females are still more devoted to their young, but the cuckoo forms a striking exception to both of these laws. The male cuckoo takes no thought whatever for his progeny, and the female gayly pursues her amorous way, depositing her eggs singly in the nests of other and usually smaller birds, which hatch them and bring up the young cuckoos with their own broods. This pe-



A SHREW LEADING HER BROOD.

culiar habit has given rise to various popular expressions referring to human marital irregularities. The most plausible explanation is that the eggs are laid at such long intervals that it would be impossible to hatch them together.

Cuckoos are rarely seen even when the air resounds with their song, for they hide as cunningly as orioles. I have never seen wild cuckoos except when the excitement of the pairing season caused them to forget their shyness. They are often kept as cage birds, but I never heard a captive cuckoo sing. The Berlin zoological garden lately possessed a white cuckoo, that had been hatched by a wheatear (*Saxicola*). Like all albinos it was sickly, and soon died.

The singular habits and mysterious appearances and disappearances of the cuckoo have given rise to many fables. It is still a popular belief that in winter cuckoos change into sparrow hawks, which they are not unlike in general appearance, though the sparrow hawk is a bird of prey, while the cuckoo is an insect-eater and therefore very useful to the farmer. Some of the ancient fables are interesting. Pliny says: "The cuckoo is produced by a bird of prey. Its egg is laid and hatched in the nest of another bird. The young cuckoo is so beautiful that its foster mother marvels that she has brought so lovely a creature into the world. Hence she despises her own young as if they were not her own, and looks calmly on while the cuckoo devours them. Her joy lasts until the cuckoo grows big enough to fly at her own throat. A cuckoo that has fattened on such fare surpasses all other game in flavor."

As a matter of fact, the young cuckoo devours neither his foster mother nor her young, though he robs the latter of their food, and sometimes expels them from the nest. Cuckoos are eaten, to this day, in Italy and Greece.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Fuer alle Welt.

THE RELATIONS BETWEEN CLIMATES AND CROPS.*

By CLEVELAND ABBÉ.

THE growth of a plant and the ripening of the fruit are accomplished by a series of molecular changes, in which the atmosphere, the water, and the soil, but especially the sun, play important parts. In this process a vital principle is figuratively said to exist within the seed or plant and to guide the action of the energy from the sun, coercing the atoms of the soil, the water, and the air into such new chemical combinations as will build up the leaf, the woody fiber, the starch, the pollen, the flower, the fruit, and the seed.

A climate that is favorable to a special crop is one whose vicissitudes of heat and rain and sunshine are not so extreme but that they can easily be utilized by the sunbeams in building up the plant. An unfavorable climate is one whose average conditions or whose extreme vicissitudes are such that the vitality of the plant, namely, its power to grow, can not make headway against them. In extreme cases, such as frosts, sudden thaws, and great droughts, the climate may even destroy the organic material that had already been formed in the plant.

No plant life, not even the lowest vegetable organism, is perfected except through the influence of the radiation from the sun. It may need the most intense sunlight of the Tropics, or it may need only the diffuse and faint light within dark forests or caves. Heat alone may possibly suffice for the roots and certain stages of growth, but a greater or less degree of light—i. e., energy delivered in short-wave length or rapid periodic oscillations—is necessary for the eventual maturity. The radiation from any artificial light, especially the most powerful electric light, will accomplish results similar to that of sunlight; therefore, it is not necessary to think that life or the vital principle is peculiar to or emanates from the sun, but on the contrary that living cells utilize the radiations or molecular vibrations so far as possible to build up the plant.

We know nothing about the nature of this vital principle, but we can, by the microscope, demonstrate that the essential ultimate structure of the plant or seed is a minute cell, namely, a very thin skin or film or membrane inclosing a minute portion of matter consisting of mixed liquids and solids. This skin is called the wall of the cell; in the early growth of the cell its inclosed liquid is called the protoplasm. By crushing many such young cells we may obtain enough of either part to make a chemical examination and find that the cell wall is a complex chemical substance called cellulose, composed of carbon, hydrogen, and oxygen. By molecules this compound is $C_{12}H_{20}O_{10}$; by weight cellulose has C 44.44, H 6.17, O 49.39 per cent. As the cells become older their walls become thicker and are incrusted internally with additional matters, such as gums, resins, etc., until the cell wall refuses to perform its original functions. Such old cells are not easily digested by man or animals and are not considered as food or reckoned among the food crops, but young cells in succulent stems, leaves, and fruits, or the crushed cells of seeds and grains, are nutritious food. Flax, cotton, jute, straw, wood pulp, and many other mature dried cells form the important crops of textile fibers.

The protoplasm within the cell is generally an albuminous compound or albuminoid, viz., besides having carbon, hydrogen, and oxygen, it also contains considerable nitrogen and a little sulphur or phosphorus or iron or other substances, thus forming albumen, whose chemical constitution is expressed by the approximate molecular formula $C_{72}H_{110}N_{16}O_{22}S_1$, or by weight C 53, H 7, N 16, O 22, S 1 per cent. Possibly this molecular formula is more properly written 3 (C_{24}, H_{28} N_4O_5), plus the addition of sulphur compounds such as to make the whole become as before written. Mulder supposed that a certain substance which he called proteine, and whose composition is supposed to be $C_{72}H_{112}N_{18}O_{22}$, is the basal molecule of albumen; two such molecules, with additional quantities of nitrogen, hydrogen, and oxygen, combined with a little sulphur, phosphorus, iron, or other mineral, make up, according to him, the constitution of the ordinary albuminoid. But his views are not considered altogether acceptable.

The constituent chemical elements contained in cellulose are precisely the same as those of starch, whose formula is $C_{12}H_{10}O_5$, but the arrangement of the atoms and molecules among themselves is undoubtedly very different, so that the physical and chemical properties of starch and cellulose are very different. Starch, diastase, and cellulose may be considered as substances composed of molecules whose internal structures are respectively more and more complex; in the molecules of each of these substances the carbon, hydrogen, and oxygen are in the same proportions relative to each other both by number and by weight, but a molecule of diastase has twice and one of cellulose three times as many atoms as a molecule of starch. The composition of pure water is represented by the molecular formula H_2O_1, or by weight H 11, O 89, so that starch may be considered as a compound of 6 atoms of carbon with 5 molecules of water. From the same point of view diastase would be compounded of 12 atoms of carbon and 10 molecules of water, while cellulose would consist of 18 atoms of carbon and 15 molecules of water. These three substances are therefore called carbohydrates, as though carbon combined with water were to be considered as carbon combined with hydric acid. This term is not to be confounded with the word "hydrocarbon," which is applied to any compound of hydrogen and carbon, which, when combined with water or other molecules, forms a very different series of chemicals, such, for example, as C_2H_6, which is a hydrocarbon and when combined with 4 molecules of water or hydric oxide forms alcohol, making the latter, as it were, a hydrate of a hydrocarbon.

The approximate percentages by weight of the cellulose found in plants and vegetables dried at a temperature of 212 deg. F. and the percentage of albuminous compounds for air-dried crops are given as follows:

Plant.	Cellulose (dried at 212 deg.)	Albuminoids (air dried).
Potato tubers	1.1	....
Wheat kernels	3.0	11-20
Maize kernels	5.5	10-16
Barley kernels	8.0	12-16
Oat kernels	10.3	11-17
Buckwheat kernels	15.0	10-14
Peas	..	22-36
Beans	..	24-41
Red clover hay	34.0	12-20
Timothy	23.0	....
Oat straw	40.0	....
Wheat straw	48.0	3-4
Rye straw	54.0	3-4

This crude chemical analysis of the walls and of the contents of the crushed cells tells us nothing of the life that had previously resided in the uncrushed organisms, but prepares us for the statement that the development of a plant implies a great amount of work done among the molecules in rearranging them into the places where they are needed. These molecules come from the simpler atoms in the soil, the air, and the rain water, but the force and energy that does the work of building them up comes, so far as we know, from the sunshine. It is a case of the transformation of energy. Within the cells of a plant the molecular energy, or the so-called "radiant energy," that would otherwise produce the phenomena of heat and light is transformed into chemical activity and produces the new molecular compounds that we use as food. We and other animals can not produce these compounds in our own bodies, but we can utilize them if they are not injured in the process of cooking.

GENERAL RELATIONS OF THE SEED AND PLANT TO THE AIR AND THE SOIL.

Respiration.

It is known that in the act of germination the seed absorbs oxygen from the air contained in the interstices of the soil and that very few seeds will germinate when the soil and the water are deprived of air or free oxygen.

As to the full-grown plant, it is commonly said to absorb carbonic-acid gas from the air through its leaves and to exhale oxygen. The investigations of Moisson tend to modify this statement and show that at low temperatures there is more oxygen absorbed than there is carbonic-acid gas produced, while at high temperatures the reverse is true. For each plant there is a certain temperature at which each volume of carbonic-acid gas absorbed is replaced by an equal volume of oxygen exhaled by the leaves. Thus in the case of the *Pinus pinaster* for every 100 volumes of oxygen absorbed there are 50 volumes of carbonic-acid gas exhaled at 0 deg. C. temperature, but 77 volumes at 13 deg. C. and 114 volumes at 40 deg. C.

Evidently this whole process of respiration depends largely upon the temperature of the air and is more active as the temperature increases. It goes on both in darkness and in light, but with this difference—that in darkness more carbonic-acid gas is given out than the oxygen that is absorbed, whereas, on the other hand, under the influence of light more oxygen is given out than the carbonic-acid gas that is absorbed. Both these processes are stimulated by heat. The assimilation or nutrition of the plant depends upon this mechanical influence of light in disengaging oxygen and "fixing" the carbon of the gas in the cells of the plant. Plant respiration is accompanied by two distinct but correlated phenomena, which are defined by Marie-Davy (1882) as "evaporation" and "transpiration."

Evaporation.—This is a purely physical phenomenon. All bodies lose water from their external surfaces when in contact with dry air, and do so faster in proportion as the wind is stronger and the air is drier. Evaporation takes place for dead and living surfaces alike.

Transpiration.—This is a physiological and not a purely physical phenomenon. It occurs only in living plants and under the influence of light; it is independent of the dryness of the air and is only indirectly dependent on temperature. It is intimately connected with assimilation, since by its means materials are furnished to complete the work of the growth of the plant.

Dryness, Temperature, and Velocity of the Wind.

The evaporation from the leaves, the flow of sap, and the development of the plant depend almost as much on the wind and the dryness of the air as they do on the temperature of the air considered by itself, since all these are necessary in order to bring the supply of nutritious water up to the leaf. Therefore, the temperature of the air must not be considered as the only important climatic element controlling vegetation. At the time of the bursting of the buds in the spring, when no leaves are on the trees and when the respiration of the plant and the evaporation are at their minimum, the temperature and dryness of the air have their least influence, while the temperature and moisture of the soil may have their maximum relative importance. These latter are the elements that determine how much water shall be absorbed and pushed upward as sap. It is under the influence of this upward pressure of the sap that the sunlight manufactures the first buds and leaves. The temperature of the air flowing among the branches and buds may have any value without seriously affecting the development of the plant, provided it is above freezing and below a destructive temperature, such as 120 deg. F., and above a destructive dryness, such as 5 or 10 per cent of relative humidity. Ordinarily a warm spring day implies a warm, moist soil and a warm, moist atmosphere. Man naturally observes first the latter feature, which is so important to him, and then associates it with the budding of the plant, but he recognizes his mistake when he considers that the plant is firmly established in the earth and that its nourishment and growth must depend primarily on the condition of the soil and roots.

Temperature and Moisture of the Soil.

The temperature of the soil a short distance below the immediate surface does not depend, by way of cause and effect, primarily on the temperature of the air. It is not warmed or cooled appreciably by conduction of atmospheric heat, but by direct absorption or loss of the radiation that falls upon it. To a slight extent (perhaps 5 per cent) this sunshine is reflected from the surface particles of the ground according to the laws of simple reflection; the remainder is absorbed by the surface and warms it. This warmed surface layer immediately radiates back a small quantity (10 per cent) as long waves into the atmosphere and through that into space, since the atmosphere does not absorb these long waves, but it gives up a larger part, perhaps 50 per cent, by conduction to the adjacent lowest layer of air, which being thus warmed quickly rises and by convection distributes this 50 per cent of heat throughout the atmosphere, whence it is eventually radiated back into space. The remaining 40 per cent of the solar heat is by conduction carried downward through the solid earth; a large portion is consumed in the evaporation of soil water and returns to the atmosphere with the aqueous vapor; the rest goes on downward, warming up the soil until it arrives at a layer 30 to 50 feet below the earth's surface, where the gradient of temperature just in front of it is the same as that just behind it. Here the heat would accumulate and push its way still deeper were it not that by this time, in most cases, the diurnal and annual changes of temperature at the earth's surface, where this heat wave started, have brought about a deficiency just below the earth's surface; consequently the heat that had reached the depth of 30 or 50 feet now finds the temperature gradient just above it beginning to reverse, wherefore this heat begins to flow back, upward, and outward. In this manner the temperature of the ground increases downward to a depth of a few yards during certain months and then upward during other months, in diurnal and annual fluctuations interspersed with irregular changes, depending on cloud and wind and rain, all of which are easily recognized by examining any system of curves representing the earth temperatures at different depths throughout the year.

The ground is warmed by the air only in case the temperature of the surface soil is lower than that of the air, and, although this happens frequently, yet the quantity of heat thereby communicated to the ground

* Abstracted from Bulletin No. 36 of the U. S. Dept. of Agriculture.

is comparatively slight, owing to the slow conductivity of the soil and the small specific heat of the atmosphere. This point has been carefully developed by Maurer, of Zurich (1885). But when rain and snow fall, then the latent heat formerly contained in the atmospheric vapor is quickly given to the surface soil and directly conducted deeper into the ground, and the latter is warmed or cooled according as the rain or snow is warmer or cooler than it. In general, the warming of the soil by warm rain is less important than the cooling by cold rains, melting snows, and evaporating winds.

Cloudiness.

When clouds intervene the soil receives a smaller proportion of direct solar heat, and the proportion diminishes as the thickness of the cloud layer increases or as the proportion of cloudy sky to clear sky increases. We may adopt the approximate rule that the warming effect of the sunshine is inversely as the cloudiness of the sky within 45 deg. of the zenith; thus for a sky covered by 10 cumulus or 10 stratus the direct solar heat at the ground is 0; for 10 cirrus or cirro-cumulus or cirro-stratus the solar heat is about 5, while for 0 cloudiness the radiation that the observer receives is 10.

Soil Thermometers.

The motions of the clouds do not affect the sum total of the intensity of the sunshine, but the variations of cloudiness are so important that it is best to make use of some form of sunshine recorder or, better still, some form of integrating actinometer as a means of determining the relative effectiveness of the sunshine for any hour or day. If any such instrument shows that during any given hour, with the sun at a known altitude, the duration of the effectiveness of the sunshine was the *n*th part of the maximum value for clear sky, then we may assume that the heating effect of the sun on the surface of the soil was the *n*th part of its maximum value and may thus ascertain and, if need be, approximately compute the irregularities of the diurnal waves of heat that penetrate the soil. But these irregularities are directly shown by thermometers buried in the soil at different depths, and the observation of such soil thermometers is an essential item in the study of climate and vegetation. The absence of these observations has necessitated much labor in unsatisfactory efforts to obtain the approximate soil temperatures from the ordinary observations of air temperature, radiation thermometers, clouds and sunshine.

Fortunately the agricultural experiment stations of the United States have begun the observation of soil temperatures as distinguished from the deep-earth temperatures that have for a century past interested the student of terrestrial physics but do not affect agriculture. I shall hereafter give a synopsis of such records so far as they are available to me; but so much agricultural data has been collected, both in Europe and America, without corresponding soil temperatures that we also need the data and methods that may be used for estimating soil temperatures from ordinary meteorological observations.

Sunshine.

Climatology usually considers the temperature of the air as given by thermometers that are shaded from the effect of sunshine; this is the temperature of the air very nearly as given by the whirled or ventilated or sling thermometers and is that which is needed in dynamic meteorology. But the sunshine produces important chemical effects besides its thermal effects, and these have no simple relation to each other. It is therefore very important that we have some method of recording the duration, intensity, and quality of the total or general radiation that the plant receives from the sun and from the sun and the sky combined. Up to the early part of the nineteenth century the optical and thermal effects of sunshine were spoken of as due to certain imponderable forces called light and heat that were supposed to be combined in the complex solar rays, but which can be separated from each other. But we now believe it to be correct to speak of the sunshine as a complex influence, a radiation of energy, whose exact nature is problematical, but whose mechanical effects when it acts upon terrestrial matter we know, measure, and study as the phenomena of light, heat, electricity, gravitation, chemism, and vitality.

Distribution of Climatic Elements Relative to the Life of the Plant.

As before stated, plants respire during both day and night. The pores of the leaves are always absorbing and emitting gases, but when the sun shines on the leaves, and more especially with the help of the yellow part of the solar spectrum, the chlorophyl in the leaf cells is able to decompose the carbonic acid absorbed by the plant, retaining carbon and rejecting the oxygen.

So long as the plant absorbs more carbon from the air and more nitrogen from the soil than it loses by any process it is continually increasing its leaf surface and the nutrition in its sap, laying up a store of nutriment for future use. This process ceases in the case of annual plants when the seed or grain or fruit begins to ripen; from this time forward the seed makes a steady draft upon the nutriment already stored up in the plant which goes to perfect the seed. In this season of growth the plant really needs less water than before, but still its roots have the same power of absorbing water, and if the sap is thus diluted there results a seed or fruit that is heavy with an excess of water. Of course this water will dry out, if it has an opportunity, after the harvest, but if it has no opportunity, on account of damp weather, it will remain in the seed and render the latter more subject to injury from fungi, whose spores are always floating in the air seeking a moist nidus or resting place favorable to their growth. Such moist seeds give a heavy green harvest, but a light dried crop.

Thus it happens that the distribution of atmospheric heat, and moisture, as to time, is quite important in its effect on the local harvest.

Apparently the time of ripening of the harvest depends wholly upon the chronological distribution of water and sunshine, but the quantity and quality of the harvest, which are the important practical results to the farmer, depend upon the nutrition carried into the plant by the water that is absorbed by the roots.

Irrigation.

The determination of the right time for irrigation and of the proper quantity of water, in order to produce the best crop in soil of a given richness, is the special problem of those planters who depend mostly upon irrigation for successful agriculture. In general it may be said that our ordinary seeds have long since been selected and acclimated with a view to success in a climate where abundance of moisture is available at the proper season. Hence our crops are not so likely to be injured by excess of rain as by deficiency or drought. Therefore in almost every section, from the Rocky Mountains to the Atlantic, the highest success can only be attained by making provision for artificial irrigation in times of drought. The exact times and quantities of irrigating water depend upon the seed, the soil, and the evaporation, which latter is due to dryness of the air, the velocity of the wind, and the character of the soil; but when artificial watering or irrigation is needed to supplement natural rain one must seek to approximate as closely as practicable to the conditions presented in the countries where the seed originated, and especially the conditions presented during the seasons in which the given seed produced the best crops.

IMPORTANCE OF CLIMATIC LABORATORIES.

The studies that we are entering upon are greatly facilitated by experiments on a moderate scale under conditions that are under the control of the investigator, and free from the irregularities of open-air agriculture. The laws of nature can only be found out by questioning nature, as it were, by means of test experiments. Our present needs in this respect are even more urgent now than they were thirty years ago, and I can not do better than to reprint and indorse the following appeal first made in an address by A. de Candolle in 1866:

"It appears to me, however, that botanic gardens can be made still more useful in carrying out physiological researches. For instance, there is much yet to be learned on the mode of action of heat, light, and electricity upon vegetation. I pointed out many of these deficiencies in 1855 in my Géographie Botanique Raisonnée. Ten years later Prof. Julius Sachs, in his recently published and valuable work on Physiological Botany, remarks much the same deficiencies, notwithstanding that some progress has been made in these matters. The evil consists in this, that when it is desired to observe the action of temperature, either fixed or varied, mean or extreme, or the effect of light, it is exceedingly difficult, and sometimes impossible (when observations are made in the usual manner), to eliminate the effects of the constant variations of heat and light. In the laboratory it is possible to operate under more exactly defined conditions, but they are rarely sufficiently persistent; and the observer is led into error by growing plants in too contracted a space, either in tubes or bell glasses. This last objection is apparent when it is wished to ascertain the influence of the gases diffused in the atmosphere around plants, or that of the plants themselves upon the atmosphere.

"Place plants under a receiver, and they are no longer in a natural condition; leave them in the open air, and the winds and currents, produced at each moment of the day by the temperature, disperse the gaseous bodies in the atmosphere. Everyone is aware of the numerous discussions concerning the more or less pernicious influence of the gases given off from certain manufactories. The ruin now of a manufacturer, now of a horticulturist, may result from the declaration of an expert; hence, it is incumbent on scientific men not to pronounce on these delicate questions without substantial proof.

"With a view to these researches, of which I merely point out the general nature, but which are immensely varied in details, I lately put this question: 'Could not experimental greenhouses be built, in which the temperature might be regulated for a prolonged time, and be either fixed, constant, or variable, according to the wish of the observer?' My question passed unnoticed in a voluminous work where, in truth, it was but an accessory. I renew it now in the presence of an assembly admirably qualified to solve it. I should like, were it possible, to have a greenhouse placed in some large horticultural establishment or botanic garden, under the direction of some ingenious and accurate physiologist and adapted to experiments on vegetable physiology; and this is, within a little, my idea of such a construction:

"The building should be sheltered from all external variations of temperature, to effect which I imagine it should be in a great measure below the level of the ground. I would have it built of thick brickwork, in the form of a vault. The upper convexity, which would rise above the ground, should have two openings—one exposed to the south, the other to the north—in order to receive the direct rays of the sun, or diffused light. These apertures should each be closed by two very transparent glass windows, hermetically fixed. Besides which, there should be on the outside means of excluding the light, in order to obtain complete darkness, and to diminish the influence of the variations of temperature when light is not required. By sinking it in the ground, by the thickness of its walls, and by the covering of its exterior surfaces with straw, mats, etc., the same fixed degree of temperature could be obtained as in a cellar. The vaulted building should have an underground communication with a chamber containing the heating and the electrical apparatus. The entrance into the experimental hothouse should be through a passage closed by a series of successive doors. The temperature should be regulated by metallic conductors, heated or cooled at a distance. Engineers have already devised means by which the temperature of a room, acting on a valve, regulates the entry or exit of a certain amount of air, so that the heat regulates itself. Use should be made of such an apparatus when necessary.

"Obviously, with a hothouse thus constructed, the growth of plants could be followed from their germination to the ripening of their seeds, under the influence of a temperature and an amount of light perfectly definite in intensity. It could then be ascertained how heat acts during the successive phases from sowing to germination, from germination to flowering, and from this on to the ripening of the seed. For different species various curves could be constructed to express the action of heat on each function, and of which there are already some in illustration of the most simple phenomena, such as germination, the growth of stems, and the course of the sap in the interior of certain cells. We should then be able to fix a great number of those minima and maxima of temperature which limit physiological phenomena. Indeed, a question more complicated might be investigated, toward the solution of which science has already made some advances, namely, that of the action of variable temperatures; and it might be determined if, as appears to be the case, these temperatures are sometimes beneficial, at other times injurious, according to the species, the function investigated, and the range of temperature. The action of light on vegetation has given rise to the most ingenious experiments. Unfortunately these experiments have sometimes ended in contradictory and uncertain results. The best ascertained facts are the importance of sunlight for greer coloring, the decomposition of carbonic-acid gas by the foliage, and certain phenomena relating to the direction or position of stems and leaves. There remains much yet to learn upon the effect of diffused light, the combination of time and light, and the relative importance of light and heat. Does a prolonged light of several days or weeks, such as occurs in the polar regions, produce in exhalation of oxygen, and in the fixing of green matter, as much effect as the light distributed during twelve-hour periods, as at the equator? No one knows. In this case, as for temperature, curves should be constructed, showing the increasing or diminishing action of light on the performance of each function; and as the electric light resembles that of the sun, we could in our experimental hothouse submit vegetation to a continued light.

"A building such as I propose would allow of light being passed through colored glasses or colored solutions, and so prove the effect of the different visible or invisible rays which enter into the composition of sunlight. For the sake of exactness nothing is superior to the decomposition of the luminous rays by a prism, and the fixing the rays by means of the heliostat. Nevertheless, a judicious selection of coloring matters and a logical method of performing our experiments will lead to good results. I will give as proof that the recent most careful experiments concerning the action of various rays upon the production of oxygen by leaves and upon the production of the green coloring matter have only confirmed the discoveries made in 1836, without either prism or heliostat, by Prof. Daubeny, from which it appears that the most luminous rays have the most power, next to them the hottest rays, and lastly those called chemical.

"Doctor Gardner in 1843, Mr. Draper immediately after, and Dr. C. M. Guillemin in 1857, corroborated by means of the prism and the heliostat the discovery of Doctor Daubeny, which negatived the opinions prevalent since the time of Senebier and Tessier, and which were the results of erroneous experiments. It was difficult to believe that the most refrangible rays, violet, for instance, which act the most on metallic bodies, as in photometrical operations, should be precisely those which have least effect in decomposing the carbonic-acid gas in plants and have the least effect over the green matter in leaves. Notwithstanding the confirmation of all the experiments made by Doctor Daubeny, when repeated by numerous physicists and by more accurate methods, the old opinions, appearing more probable, still influenced many minds till Prof. Julius Sachs, in a series of very important experiments, again affirmed the truth. It is really the yellow and orange rays that have the most power, and the blue and violet rays the least, in the phenomena of vegetable chemistry, contrary to that which occurs in mineral chemistry, at least in the case of chlorid of silver. The least refrangible rays, such as orange and yellow, have also the twofold and contrary property, such as pertains also to white light, and which pro-

duces the green coloring matter of leaves or bleaches them according to its intensity. It is these, also, which change the coloring matter of flowers when it has been dissolved in water or alcohol. Those rays called chemical, such as violet and the invisible rays beyond violet, according to recent experiments confirmatory of those of ancient authors—those of Sebastian Poggioli in 1817 and those of C. M. Guillemin—have but one single well-ascertained effect, that of favoring the bending of the stem toward the quarter from which they come more decidedly than do other rays; yet that is an effect perhaps more negative than positive if the flexure proceeds, as many still believe, from what is going on on the side least exposed to the light.

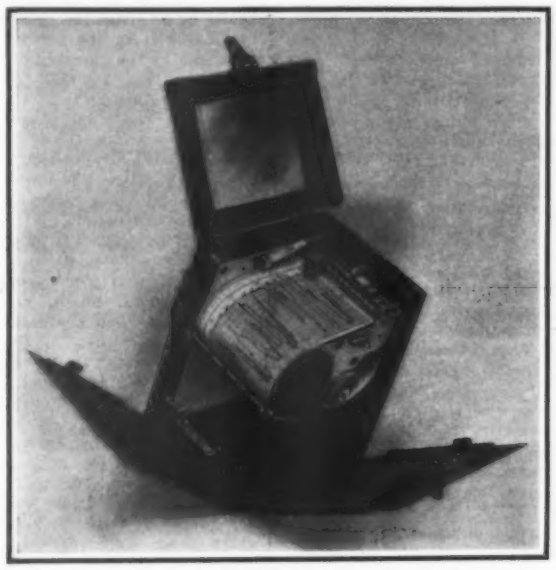
"The effect upon vegetation of the nonvisible calorific rays at the other extremity of the spectrum has been but little studied. According to the experiments we have on this subject, they would appear to have but little power over any of the functions; but it would be worth while to investigate further the calorific regions of the spectrum by employing Doctor Tyndall's process—that is, by means of iodine dissolved in bisulphide of carbon—which permits no trace of visible light to pass.

"How interesting it would be to make all these laboratory experiments on a large scale! Instead of looking into small cases or into a small apparatus held in the hand and in which the plants can not well be seen, the observer would himself be inside the apparatus and could arrange the plants as desired. He might observe several species at the same time—plants of all habits, climbing plants, sensitive plants, those with colored foliage, as well as ordinary plants. The experiment might be prolonged as long as desirable, and probably unlooked-for results would occur as to the form or color of the organs, particularly of the leaves.

"Permit me to recall on this subject an experiment made in 1853 by Prof. von Martins. It will interest horticulturists, now that plants with colored foliage become more and more fashionable. Prof. von Martins placed some plants of *Amaranthus tricolor* for two months under glasses of various colors. Under the yellow glass the varied tints of the leaves were all preserved. The red glass rather impeded the development of the leaves and produced at the base of the limb yellow instead of green; in the middle of the upper surface, yellow instead of reddish brown, and below, a red spot instead of purplish red. With the blue glasses, which allowed some green and yellow to pass, that which was red or yellow in the leaf had spread, so that there only remained a green border or edge. Under the nearly pure violet glasses the foliage became almost uniformly green. Thus, by means of colored glasses, provided they are not yellow, horticulturists may hope to obtain at least temporary effects as to the coloring of variegated foliage.

"The action of electricity on foliage is so doubtful, so difficult to experiment upon, that I dare hardly mention it; but it can easily be understood how a building constructed as proposed might facilitate experiments on this subject. Respecting the action of plants on the surrounding air and the influence of a certain composition of the atmosphere upon vegetation, there would be by these means a large field open for experiments. Nothing would be easier than to create in the experimental hothouse an atmosphere charged with noxious gas and to ascertain the exact degree of its action by day and by night. An atmosphere of carbonic-acid gas might also be created, such as is supposed to have existed in the coal period. Then it would be seen to what extent our present vegetation would take an excess of carbon from the air, and if its general existence was inconvenienced by it. Then it might be ascertained what tribes of plants could bear this condition and what other families could not have existed, supposing that the air had formerly had a very strong proportion of carbonic-acid gas."

In hopes of realizing this idea of a complete botanic laboratory, the author spent his vacation in 1893 in the botanic gardens and greenhouses of Harvard University. On his return to Washington Prof. Riley kindly offered him every convenience and space in the insectary of the Department of Agriculture. His 300 experimental plants of wheat and maize were, therefore, brought hither from Cambridge, Mass. But unforeseen difficulties arose, and it is to be hoped that the idea of an experimental laboratory for botanic study may be carried out by abler hands.



SPEED AND MILEAGE RECORDER, SHOWING CHART AND RECORDING STYLUS, WITH SPEEDS RECORDED.

A SPEED AND MILEAGE RECORDER FOR AUTOMOBILES AND RAILROADS.

IN view of the constant necessity of accurately determining the speed and mileage of mechanically-propelled vehicles for experimental and other purposes, a positive recorder for this work is urgently required. Innumerable devices have been devised for fulfilling these functions, but they have failed to fulfill all the functions which should be characteristic of such an appliance. In carrying out speed tests, whether it be with a locomotive, automobile, or electric railroad, certain deductions or corrections of the recorded result have been necessary to obtain the correct quantity desired. In the majority of these recorders certain allowances have to be made for stoppages or other unforeseen circumstances incidental to speed experiments or investigations, with the result that the final deductions involve considerable calculation, and are even then open to doubt.

Recently, however, a new type of recorder has been introduced in Great Britain by the Motor and Tram Speed Recorder Company, of Birmingham, which fulfills all the requirements of the experimenter and is infallible in its operation, as repeated trials with it upon railroads and automobiles have demonstrated. This machine is a decided advance upon any instruments that have been devised so far, for this exacting class of work. In the first place, it records the actual time of starting of the vehicle upon which it is being used, records the various actual speeds with the constant fluctuations during the whole time it is in motion, the time taken to each mile, the variation of speed minutely recorded between each mile, and what is of the utmost importance in such an apparatus, the duration of each stop.

The general appearance of the apparatus, together with its principle of operation, may be gathered from the accompanying illustrations. It essentially comprises a governor driven either by a friction wheel or by a positive drive. In the case of an automobile the friction wheel is driven by one of the rear wheels, but for locomotives and electric street surface railroads the driving wheel runs on the track itself, and is thus independent of the driving wheels of the vehicle. This recorder driving wheel is maintained in its correct position by means of a spring, which keeps it at an even tension. The friction wheel has an unvarying circumference of 18 inches, and can be applied to wheel tires of any diameter; and as every second revolution counts one yard of travel, the mileage recorded is exactly that covered by a car wheel of any varying diameter. Furthermore, deflation of the tire makes no difference in the accuracy of the distance recorded.

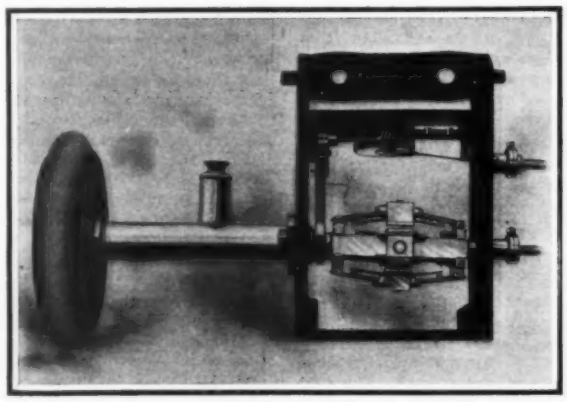
The drive from the governor to the scriber is direct by Bowden cable. The scriber travels on a worm, and makes an indelible and permanent record. The latter is contained on a revolving drum. Longitudinally it is divided into hours and subdivided into minutes. Transversely it is divided into miles, while in addition a special record of every mile covered is made with a dot. In general appearance the record resembles that produced upon a barograph, as one is able to discern at a glance the pace of the vehicle at any desired minute, and the number of miles covered in a certain length of time, without any calculation or allowances of any kind.

The chart is actuated by clockwork at the rate of four inches per hour, the chart continuing the record when the car is stationary by a straight line at the zero point. It is thus easy to obtain the mean running time of the vehicle during a certain period by the simple deduction of the stationary time from the gross result. The special record upon the completion of every mile is carried out by means of a cam and gearing in the governor box, to which a second cable is attached, actuating a pen in the recording instrument.

The recording portion of the instrument is carried upon the dashboard of the automobile directly in front of the driver, so that he can at any moment ascertain his average speed. Another prominent feature of the apparatus is the automatic control with which it is fitted. This is an invaluable device, since the owner or passenger in the vehicle can set the limit of speed at which he desires to travel, and it is impossible for the driver to exceed that maximum, since directly the car exceeds the limit the electric current is cut out, and the connection automatically restored immediately the car has slowed down to the requisite speed. The record also being absolutely positive, the driver cannot interfere with its operation, since any attempt to tamper with the authenticity of the recording instruments is shown upon the graduated scale, the pen showing an instant drop and consequent rise.

The instrument has been severely tested upon speed trials with electric street railroads in Great Britain. In such cases, where the cars are only permitted to attain a maximum speed and the apparatus is set thereto, directly the vehicle exceeds the maximum, the driver is warned of the fact by an alarm bell, which commences automatically to ring and continues until the driver has slackened to within the prescribed limit. There is a special dial placed horizontally in front of the driver, with the miles per hour indicated, and there is a pointer similar to that of a compass, which demonstrates to the driver the precise speed at which he is driving the car.

The most important feature of the recorder in its application to this field of operations, is that the velocity of the car is registered independently of the revolutions of the car wheels—a most vital point—as the wheel actuating the instrument is running on the track itself. The value of this feature may be realized, since even after the power is switched off and the wheels braked, the vehicle will often, especially upon a decline, or on rails slippery with water, slide for several yards even with the wheels securely locked. No matter how often, or how great the length of this skidding distance, the recorder accurately measures the extent of the slide, together with the speed of the car at the time. In cases of accidents such a record is invaluable, since the instrument offers irrefutable testimony upon the point of speed at which the vehicle was traveling at the time, together with the extent of control shown by the distance which the wheels skidded. Although the wheel driving the recorder is of small diameter, the means observed to keep it constantly in contact with the track are such that it will not jump the track when traversing sharp curves at a high speed, on crossovers, or when the gradient is suddenly changed. Col.



OPERATIVE MECHANISM OF THE RECORDER, SHOWING THE MEASURING WHEEL.

Yorke, the well-known authority to the Parliamentary Board of Trade, has subjected the instrument to several severe tests, but it has never failed to supply a faithful record of the work accomplished even under the most adverse circumstances, and he has expressed himself as completely satisfied with its accurate working.

For railroad locomotive work the apparatus is exactly the same, except that the graduated chart is made to revolve at the rate of twelve inches per hour instead of four. The recorder has proved accurate in operation up to a speed of 80 miles per hour, but this speed does not signify the limit of its capacity, since it can be extended *ad lib.*

It will be observed that the apparatus is mechanically operated throughout, which design conduces to its accurate and infallible working, which might not otherwise be possible were there any electrical or pneumatic attachments. Neither can its accuracy be impaired, owing to the drive adopted, which is positive, for belts might exercise a tendency to slip at fast speeds or under the influence of continued use. Furthermore, being of simple construction, the liability of any part of the mechanism to become deranged is remote.

OBSERVATIONS AND SUGGESTIONS CONCERNING LIGHTNING RODS.

IT has been pointed out by Sir Oliver Lodge that lightning discharges are of two distinct characters, which he has named the *A* flash and the *B* flash, respectively. The *A* flash is of the simple type which arises when an electrically charged cloud approaches the surface of the earth without an intermediate cloud intervening, and under these conditions the ordinary type of lightning conductor acts in two ways: first, by silent discharge; and secondly, by absorbing the energy of a disruptive discharge. In the second type, *B*, where another cloud intervenes between the cloud carrying the primary charge and the earth, the two clouds practically form a condenser; and when a discharge from the first takes place into the second the free charge on the earth side of the lower cloud is suddenly relieved, and the disruptive discharge from the latter to the earth takes such an erratic course *that no series of lightning conductors of the hitherto recognized type suffice to protect the building.*

On the 28th of May, 1904, an interesting demonstration of the action of *A* and *B* flashes, respectively, was given by Sir Oliver Lodge. A thin sheet of metal mounted on non-conducting standards represented the cloud, which was charged at will from a Leyden jar. The "cloud" was so arranged that the model lightning conductors could have their points brought nearer to or farther from its under surface by shifting their positions on the table. Conductors of copper, iron, and wet string were experimented with. The disruptive discharge to the copper proved to be by far the loudest and most intense of the three. The iron took the flash with less noise, the wet string with hardly any; yet when the discharge passed through it the other, and apparently better conductors, were not affected. The experiments tended to demonstrate that iron is in many situations a very useful material for lightning rods, as the effective energy of a flash of lightning is rapidly dissipated in iron. This metal, however, unfortunately oxidizes rapidly in towns and smoky districts, and the use of copper as a material for a lightning rod is still recommended for main conductors in relatively inaccessible positions, although iron is electrically preferable.

It is probable that with few exceptions buildings are not in reality efficiently protected against the effects of a *B* flash, although in many cases the lightning conductors may be said to have at least partially fulfilled their purpose by carrying off the more violent portion of a discharge, and that without them greater damage would have occurred in many of the cases reported.

Some of these observations throw a very interesting light on the effects due to the oscillatory character of lightning discharges. For instance, a discharge takes place over a lightning rod which may be in contact with, or approach closely to, the metallic portions of a roof. Powerful electrical oscillations are set up in the latter conductors, and dangerously high electrical pressure may be generated on the distant ends of these conductors. If at these points they were connected to earth the pressure would be relieved, and the discharge harmlessly dissipated. Without this safe path the discharge may break away into the down pipes, or may pierce the roof to reach internal conductors. Cases which appear to indicate successive or simultaneous flashes may be due to a single flash setting up these oscillations.

In some cases the damage done to a building by an *A* flash is not necessarily due to the primary discharge. A lateral discharge occasionally occurs which frequently causes minor, though in some cases serious, damage owing to falling materials.

Many of the reports of damage to unprotected buildings show that the lightning discharge followed the path of wire ropes, metallic pipes, and other conductors, and that the damage to the structure occurred at the breaks in continuity at the upper and lower terminals, respectively.

It may be considered that a lightning conductor of the ordinary type, if properly constructed, affords an undefined area of protection against *A* flashes, but it cannot be said to have any protective area against *B* flashes.

Absolute protection of the whole of a building could be assured only by inclosing the structure in a system of wirework—a contrivance, in fact, of the nature of a bird cage. This should be well connected at various points to earth, as nearly all buildings have gas and water pipes and other metallic conductors in their interiors which are likewise earthed. For structures intended for the manufacture or storage of gunpowder and other explosives the adoption of this bird cage protection would be justified on the score alone of

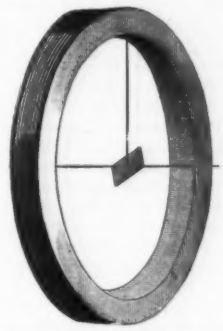


FIG. 1.—PRINCIPLE OF TANGENT GALVANOMETER.

public safety. Architectural considerations prevent the adoption of such a method in its entirety for ordinary buildings. There is no doubt, however, that practically perfect protection may be assured by a judicious modification of the existing practice of erecting single lightning rods, especially in the case of extensive and lofty buildings that project well above surrounding structures or that stand isolated in the open country.

It is obvious that the extent to which the building should be protected and the expense to be incurred in this protection must bear some definite relation to the importance or cost of the building itself. In cases

FIG. 2.—TANGENT GALVANOMETER.

where protection is considered desirable, but heavy expense is not justified, two or more lightning rods might be erected in the ordinary manner, these being connected by a horizontal conductor, and the metal portions of the roof and the rain water down pipes should be metallically connected and well earthed.

Tall chimney shafts are not efficiently protected against a *B* flash by an ordinary single lightning rod, as a hot column of smoke issuing from a chimney conducts as well or even better than a rod. A circular band should surround the top of the shaft; four or more conductors should be raised above the latter in the form of a coronal, or the continental practice of

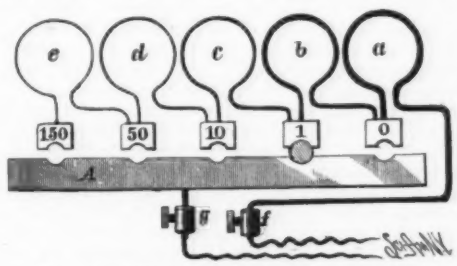


FIG. 3.—ARRANGEMENT OF SWITCH CONNECTIONS.

joining the elevation rods together, so as to form an arch over the chimney, may be employed with advantage. One, or, preferably, two lightning rods should extend from this circular band to the earth in the manner described below.

As most buildings contain systems of gas and water pipes, a good earth for the lightning conductors is highly desirable. In the case of a stove inside a building with a metallic stove-pipe carried outside, the stove should be earthed, and a wire be led from the pipe to earth outside, or to the nearest conductor.

The various cases noted by the committee show that while even single conductors tend to diminish the damage done to buildings by lightning no reliance can be placed on an area of protection. Judging by the latest foreign practice, continental experience appears to be confirmatory of this view. In churches and other buildings with spires and towers the lower projections should also be protected, even if forming part of the salient features of the building.

No cases of damage to modern steel frame structures have come under the notice of the committee. The ordinary method of construction, however, in this country does not provide full protection. In many cases the steel columns stand on stone foundations and the metal is not carried deep enough for effective earthing. The metal columns ought to be earthed at the time of construction.

TANGENT GALVANOMETER.

THE tangent galvanometer is of great importance in electrical measurements, especially in the class relating to currents. The principle of the instrument is illustrated by Fig. 1. In a narrow coil of wire is suspended a short magnetized needle, whose length does not exceed one-twelfth the diameter of the coil. Two light pointers are connected with the needle at right angles thereto. When a current is sent through this coil, the needle is deflected to the right or left, according to the direction of the current, and the amount of deflection is dependent upon, but not proportional to, the strength of the current. It is, however, proportional to the tangent of the angle of deflection.

A practical tangent galvanometer is shown in Fig. 2. In this instrument the conductor is wound upon a grooved wooden ring 9 inches in diameter, the groove being ¾ inch wide and 1 inch deep. The wooden ring is mounted in a circular base piece, which is pivoted to the lower base to admit of adjustment. The lower base is provided with three leveling screws, which are bored longitudinally to receive pointed wires, which are driven into the table to prevent the instrument from sliding. The lower base is provided with an angled arm, which extends over the upper base piece, and is provided with a screw for clamping the latter when adjusted.

The winding of the ring is divided into five sections having different resistances, so that by means of a plug inserted in the switch on the base the resistance may be made 0, 1, 10, 50, or 150 ohms.

Fig. 3 is a diagram showing the coils and the switch connection stretched out. The first coil, *a*, is a band of copper ¾ inch wide and 1/16 inch thick, with practically no resistance. The other coils are of iron. The coils *b* and *a* together have a resistance of 1 ohm; coils, *c*, *b*, *a*, have a combined resistance of 10 ohms. The coil, *d*, together with the preceding, offer a resistance of 50 ohms and the combined resistance of all of the coils, *e*, *d*, *c*, *b*, *a*, is 150 ohms.

The conductors are connected with the binding posts, *f g*, and the current flows through the coils in succession, until it reaches one of the smaller switch plates, which is connected with the plate, *A*, by the plug. In the present case the plug is inserted between the plate marked 1 and the plate, *A*, causing the current to flow from the binding post, *f*, through the coils, *a*, *b*, and plate, *A*, to the binding post, *g*. The resistance of the galvanometer is obviously 1 ohm.

The magnetic needle, which is ¾ inch long, is located exactly at the center of the ring, and delicately poised on a fine hard steel point. The needle should be jeweled to reduce the friction and wear to a minimum. To the sides of the needle are attached indexes of aluminium having flat ends, each of which is provided with a fine mark representing the center line of the index. The box containing the scale and the needle is supported by a cross bar attached to the wooden ring. To the top of the wooden ring is attached a brass standard, which is axially in line with the compass needle.

Upon the standard is mounted a bar magnet, which may be adjusted at any angle or raised or lowered. This magnet serves as an artificial meridian when the galvanometer is used for ordinary work. When it is used as a tangent galvanometer the magnet is removed.

The tangent galvanometer must be arranged with the coil and the needle in the magnetic meridian, and its adjustment must be such that a current which produces a certain deflection of the needle in one direction will, when reversed, produce a like deflection in the opposite direction. The angle of maximum sensitiveness in the tangent galvanometer is 45 deg.; therefore, when it is possible to do so, the current should be arranged to produce a deflection approximating 45 deg.

The resistance of a battery may be ascertained by means of the tangent galvanometer as follows: The battery is connected with the galvanometer, and the deflection of the needle is noted; then a variable resistance is introduced and adjusted until there is a deflection, the tangent of the angle of which is equal to one-half the tangent of the angle of the first deflection. The resistance thus introduced is equal to that of the battery and galvanometer. Take from this quantity the resistance of the galvanometer and the remainder will be the resistance of the battery.

For example, when a battery placed in circuit with a tangent galvanometer produces a deflection of 48 deg., the tangent of that angle being 1.111, half of this quantity would be 0.555, which is very nearly the tangent of the angle of 29 deg.; therefore, resistance is introduced until the needle falls back to 29 deg. Assuming this resistance to be 15 ohms, and the resistance of the

galvanometer to be 10 ohms, the galvanometer resistance deducted from the resistance introduced leaves 5 ohms, which is the resistance of the battery.

To measure the electromotive force of a battery a standard cell is necessary. A Daniell or gravity cell, having an E. M. F. of 1.079 volts, is commonly used. This is connected with the tangent galvanometer, and the deflection and total resistance in the circuit, which must be high, is noted. The standard battery is then removed and the one to be measured is inserted in its place, and the resistance of the circuit is adjusted until the deflection of the galvanometer needle is the same as in the first case. It now becomes a matter of simple proportion, which is as follows:

E. M. F. of standard battery	:	E. M. F of battery being measured,	: :	Total resistance in first case.	:	Total resistance in second case.
1.079	:	Unknown E. M. F.	: :	2,500	:	2,000

Assuming the resistance in the first case to have been 2,500 ohms, and that in the second case 2,000 ohms, the proportion would stand thus:

or as 5 to 4. The E. M. F. of the battery measured is therefore 0.8632 volt.

A convenient arrangement of the tangent galvanometer scale is to have one side of the scale divided into degrees, the other side being arranged according to the tangent principle, so that the reading will be direct and reference to the table of tangents will be avoided.

The simplest method of measuring resistance is that known as the substitution method, in which the unknown resistance and a galvanometer are placed in the circuit of the battery; the deflection of the galvanometer needle is noted. A variable known resistance is then substituted for the unknown resistance, and adjusted until the deflection is the same as in the first case. The variable known resistance will then equal the unknown resistance. If the current is so great as to cause a deflection of the needle much exceeding 45 deg., it should be reduced either by removing some of the battery or by the introduction of extra resistance into the circuit. The same conditions must obtain throughout the measurement.

REMINISCENCES OF SEVENTY-ONE YEARS IN THE COTTON SPINNING INDUSTRY.*

By STEPHEN A. KNIGHT, Providence, R. I.

ON the first day of April in the year of our Lord one thousand eight hundred and thirty-five the writer of this paper commenced his labors in a cotton mill as bobbin boy, or, as it was termed in those days, back boy. The mill was in the State of Rhode Island, being in the town of Coventry. It was owned by a man who was at one time Governor of Rhode Island, a man who was a progressive and intelligent manufacturer. His mill was "up-to-date" and among the most successful in the country at that time.

My work was to put in the roving on a pair of mules containing 256 spindles. It required three hands—a spinner, a fore side piecer, and a back boy—to keep that pair of mules in operation. The spinner who worked alongside with me died about two years ago at the age of one hundred and three years, an evidence that all do not die young who spend their early life in a cotton mill.

The running time for that mill, on an average, was about fourteen hours per day. In the summer months we went in as early as we could see, worked about an hour and a half, and then had a half hour for breakfast. At twelve o'clock we had another half hour for dinner, and then we worked until the stars were out.

From September 20 until March 20, we went to work at five o'clock in the morning and came out at eight o'clock at night, having the same hours for meals as in the summer time.

For my services I was allowed forty-two cents per week, which, being analyzed, was seven cents per day, or one-half cent per hour.

The proprietor of that mill was accustomed to make a contract with his help on the first day of April, for the coming year. That contract was supposed to be sacred, and it was looked upon as a disgrace to ignore the contracts thus made. On one of these anniversaries, a mother with several children suggested to the proprietor that the pay seemed small. The proprietor replied, "You get enough to eat, don't you?" The mother said, "Just enough to keep the wolf from the door." He then remarked, "You get enough clothes to wear, don't you?" to which she answered, "Barely enough to cover our nakedness." "Well," said the proprietor, "we want the rest." And that proprietor, on the whole, was as kind and considerate to his help as was any other manufacturer at that time.

The opportunities for an education among the factory help were exceedingly limited, as you can well see, both from the standpoint of time and from the standpoint of money.

But, gentlemen, we are living in better days. We work less hours, get better pay, live in better homes, and have better opportunities to obtain an education.

The power for the mill that I have mentioned was taken from the north branch of the Pawtuxet River onto a breast wheel, connected with segment gears, to an upright shaft by a pinion gear. The wheel was in about the center of the mill and occupied a space on the first floor about twenty feet long and about three-quarters of the width of the mill, full height of the first story which was the weaving room. The upright, as well as most of the shafting in the mill, was square, turned only where the bearings came. A main line ran from the upright each way and was driven by a crown wheel and bevel pinion gears.

The upright ran up through the entire mill. The driving pulleys, or, more properly speaking, the drums, were wood with iron clamps to connect them to the shafting, made tight and trued up with iron wedges. The belting was made by the overseer in each room from sides of leather just as it came from the tannery.

The cotton came to the mill in large, uncompressed square bales tied with ropes, or sometimes in round bales without ropes, but always soft and fleecy, so I was comparatively easy to spread on the card. There was no lapper. The cotton was fed by hand onto an apron attached to the card and driven by a band or belt. The apron was marked in sections and a certain amount of cotton, spread by hand, on each section.

The cylinders of the cards were 18 inches in length, and as I remember 42 inches in diameter. The frames were made of wood, and a cumbersome machine they were.

The stripping was done by hand and an expert stripper was paid three shillings and sixpence, or 58 cents, per day.

The sliver from the breakers—it was double carding—was then run through a doubler into laps, next through the finisher, and from the finishers in cans to a three-roll drawing machine, which was rather a crude one. It had a wooden table, and wooden legs for its support, and had neither stop motion or evener.

From the drawing the sliver was carried to the speeders, which were called "Taunton speeders." I don't know what gave them that name; perhaps they were made in Taunton. I presume some of you gentlemen have seen some of these machines running.

The roving had no twist but was compressed by running through an endless belt, made of woolen cloth or listing. The doubling was light. The evenness of the yarn depended largely on the uniform spreading of the cotton on the cards and the vigilance of the drawing tenders.

The spinning frames were throstle or flyer frames. They had 24 spindles on a side and 48 spindles to a frame. The cylinders were made of wood and the spindle rails were also made of wood. On No. 24 yarn the front roll ran from 38 to 42 turns per minute. The pay for tending these frames was 25 cents per side and a good spinner could tend from 8 to 10 sides.

The yarn was spooled on drum spoolers, warped on warpers without stop motions, and dressed on dressing machines quite similar to those commonly used up to the time when the slasher came into use.

The mules were rather a clumsy piece of machinery. The heads, roller beams, and sampsons were of wood. The drums were also made of wood with an iron rim attached, scored for the drum band. The average spinner made about five dollars per week. Later on some of these mules were doubled up, that is, two pairs were made into one pair with the heads in the middle. I well remember when the first pair of mules, so changed, were about ready to start. I was looking them over, I presume, quite knowingly. The superintendent said, "Well, Stephen, what do you think of it?" I answered, "Where are you going to put the waste box?" He replied, "We think of putting it on the flywheel." I was not asked for, nor did I give my opinion again that day.

The looms were quite rudely made, and were speeded from 60 to 70 picks per minute. Weavers made all the way from three to five dollars per week. Overseers were paid from six to seven and a half dollars per week, he being an uncommonly bright man who could command the latter price.

The chore men, outdoor men, and men of all work were paid all the way from four to six dollars per week. I have been particular in giving the prices paid for the different departments and the hours worked, in order that you may contrast the vast advantage that labor has to-day over that of seventy years ago.

I worked in the mill mentioned about eleven years. Great improvements were made in that time. Wider cards were got and a lapper was installed. A new drawing with a stop motion took the place of the old. Geared speeders were introduced. Ring spinning was substituted for the throstle frames, and many minor improvements were adopted that improved the quality of the goods and reduced the cost of production.

It is not my purpose to speak of the many improvements of recent date, but leave it for you to compare to-day with the conditions of seventy years ago.

I have previously said, "We work less hours, get better pay, live in better homes, and have better opportunities for obtaining an education." In the place of eighty-four hours we now work fifty-eight hours per week, a difference of twenty-six hours, and as an employer of help I am glad of it. We are not allowed to employ children at the tender age that was in vogue seventy-one years ago. As an employer of help I am glad of that. We get better pay for our services. There is at least an advance of two hundred per cent, and in many cases more than that. We live in better homes; our houses are larger, better finished, and kept in better repair. When I was a boy, if we wanted a room repapered or painted, or even whitewashed, we had to do it at our own expense. It is quite different now. Every village of any size employs painters and other help enough to keep our houses in good, neat, and healthy condition, while the sanitary conditions receive especial care.

Many of our employes have homes of their own, built with money earned in our manufactories, a thing almost unknown seventy years ago.

The opportunities for obtaining an education are almost all that can be desired. We have the kindergarten, the primary, the grammar, and the high schools in most of our villages; and then we have the school of technology, the manual training school, and the textile school.

* Read before the New England Cotton Manufacturers' Association.

THE EARLY USE OF IRON.

THERE is no subject in the history of metals of more interest than that which relates to the early use of iron. Recent investigations prove that its application to the arts of war and peace extends farther back than was formerly thought to be the case; and it is easy to understand the failure to recognize its antiquity when we remember how great is its liability to change by oxidation as compared with its rival, bronze. Mr. Bennett H. Brough, in a very interesting lecture delivered at Glasgow, brought together, within reasonable compass, most of the material facts bearing on the question; and added some interesting matter as the result of his own researches. The task is one he is admirably fitted to perform by reason of his metallurgical training and archæological knowledge. In dealing with the debatable question as to prehistoric implements of iron having been made from a meteoric nickel-iron alloy, he pointed out in his paper that such an origin for early iron implements is open to considerable doubt, owing to the difficulty of working meteoric iron; although he acknowledges that some meteoric iron is malleable, and that there are undoubted cases in which it has been successfully forged. The difficulty remains, however, of tools suitable for cutting meteoric iron not having existed in early days; and the lecturer was of opinion that the first discovery of iron was due to the accidental melting of a rich iron oxide with charcoal. Mr. Brough mentions the large block of meteoric iron found in Greenland, and now in the New York Museum of Natural History. This remarkable "meteoric stone" is of irregular shape, 11 feet by 7½ feet by 6 feet, and weighs nearly 50 tons. Iron was undoubtedly used in the building of the Pyramids, 3000 B. C., the working of granite and porphyry being scarcely conceivable without steel tools. There is in the British Museum an iron sickle which was found under one of the sphinxes at Karnak. Mr. Brough mentions another historic piece of iron, also preserved in the British Museum. It is part of a tool, and was found in the Great Pyramid, and so must be nearly 5,000 years old. This is more interesting in the light of recent metallurgical practice, as it contains not only nickel, but also combined carbon, thus showing that it is not of meteoric origin. A further anticipation of what we look on as modern practice was the iron bedstead of Og, King of Bashan. He was "of the remnant of giants;" as well he might have been, for his bedstead was 16 feet 6 inches long and 7 feet 4 inches wide. Another interesting piece of early ironwork is more modern, dating back to less than a thousand years B. C. This is an iron pillar, still existing at Delhi. It is 50 feet high and 16 inches in diameter, and, as Mr. Brough tells us, it is made up of 50-pound blooms welded together. As the early methods of iron and steel manufacture were brought from India to Europe, this mass of wrought iron—large even in the present day—may be looked on as the *doyen* among the products of the heavy-iron industry. In the Far East the use of iron and steel has been traced back in China to the year 2357 B. C., or about eleven hundred years before Japan was colonized from that country. The Japanese are said to have followed a method of making steel which had the merit of simplicity. They buried forged iron bars in marshy ground, and what was left of them after eight or ten years, by some curious alchemy, came out steel. The iron industry of England is, beside that of Egypt or China, quite modern. The Emperor Hadrian, Mr. Brough tells us, founded an arms factory nearly 1,800 years ago, getting iron from the Forest of Dean mines; and the slag-heaps in Sussex testify to the extensive iron works in the south during the Roman occupation. The more modern history of the metallurgy of iron will be known to most of our readers.

THE USE OF DIVERS IN MINING.

IN order to take out machinery, tools, pipe lines, etc., from mines that are filled with water, it is very often possible to use a diver. The kinds of apparatus used by divers in Germany are of two principal types, the English and the German system. In the former system the diver is clothed in an air-tight suit with a metallic helmet. The suit is filled with air and a hose is attached to furnish fresh air. The diver inhales what air he requires, and the air which he exhales mingles with the fresh air inside of the helmet. In order to relieve the excess of air, a valve which works automatically is attached, allowing the air to escape when the pressure passes a certain limit. The diver has control of this valve, and by a sidewise movement of the head can open it at will. The system has the disadvantage that the diver is not breathing pure air, and his lungs are subject to the pulsations of the pump by which the air is furnished. Also his safety depends more or less on the strength of the diving suit. The German system differs from the English in that the diver carries with him an air receiver which is divided into two parts by a partition. One of these parts serves as fresh-air reservoir, and the other one is connected with the mouth of the diver by means of a rubber tube. By a simple valve in this partition the pressure is equalized as he breathes. The

complete apparatus consists of the suit, the helmet, breathing tube, the tank, the air pump and air hose, cages, weights, signal line and belt with knives. The use of these several parts is well known. By a special valve the air which has been breathed is discharged from the tank. Some cases in which divers have been used may be of interest.

In the shaft of the Upper Silesian Coke Works, at Marienberg, it was necessary to move under water three collapsed stagings, a Weisel pump, a hand pump, boring tools, wire rope, and electric wires. The working place in which this task was accomplished was 338 meters below the surface, and the column of water through which the diver had to work was from 6 to 22 meters. On account of the continuous evolution of carbonic acid the water was considerably agitated and this fact made the work extremely difficult. The water was coming in at the rate of 3 to 4 cubic meters a minute. The greatest danger was the explosive gas which at times was so pronounced that the men could not work at the surface of the water. As a precautionary measure extra lengths of hose had been provided so that the air pump of the diver could be placed 40 to 50 meters above the water surface. After dismantling the machinery, which was accomplished without any special accident, on the last day there was an enormous eruption of carbonic acid which made the water column boil and rise about 4 meters, but there was no loss of life. The diver's safety in this case may be attributed to the excellence of his apparatus. In the No. 2 shaft of the Hetty Mine, in Vetschau, it was necessary to dismantle four pulsometers. The shaft was abandoned in 1897 and it filled with water. These pumps were about 37 meters under water. The shaft was clear down to the water level. The pulsometers were fastened to heavy timbers. A hand winch was used in hauling out the pumps. The diver made everything clear, attached the line to the upper pulsometer, then broke the pipe connections and the pulsometer swung freely in the shaft. The second one of these pumps was pulled out together with the suction and part of the steam pipe. The work of taking these four pumps out of the mine, together with the building of staging in the shaft, took seven days, although only one diver was used.—From Mines and Minerals.

SCIENCE NOTES.

A remarkably fine specimen of a rare hybrid was exhibited at a recent meeting of the British Ornithologists' Club. This was a cross between the blackcock and pheasant, and the bird displayed the characters of the male of both species, the under parts being glossy black shot with steel blue, but showing traces on the sides of the mahogany red and black spots of the pheasant; while the upper parts resembled those of the young blackcock. The tail was rounded but without bars, and similarly the legs showed a compromise between the two species, the upper parts being feathered and the lower covered with scales.

A new species of frogs hitherto unknown was described at a recent meeting of the British Royal Zoological Society. This frog is of massive proportions, measuring no less than ten inches in length from the snout to the end of the body. It has been named *Rana Goliath*, and is found in the South Cameroons. A live specimen was secured by one of the officials of the society during a recent expedition. When captured it was placed for safety in a barrel and partly covered with a lid. Unfortunately, however, the latter was accidentally removed and the frog escaped. Another interesting exhibit at the same meeting was a stuffed specimen of a remarkable frog, the females of which carry their eggs in the mouth until they are hatched. The young emerge not as tadpoles, but as fully-formed though diminutive frogs.

The most important aspect of the scientific spirit is its application to the needs and comforts of mankind. The real business of applying science is the work of the engineer; he has dug our canals, built our bridges, laid out our railroads, and has furnished the necessary technical skill for our great industrial enterprises. The engineer imbued with the scientific spirit has existed only within the last half century. The whole process of recognizing engineering as a science, of realizing its importance to industry, and of thinking and acting in accordance with the scientific spirit is comparatively a very recent affair. The eminent men so often named as early engineers were endowed with a genius for construction, but they were never quite sure of their results until they had wasted time, money, and material, sufficient, perhaps, to duplicate their structures. These great constructors cannot be placed in the same class with our modern scientific engineer, who, if he were to follow their example, would soon be without clientage. The difference between the great constructors of the past and the scientific engineer of to-day is that the latter is imbued with the scientific spirit. He has utterly discarded the rule-of-thumb principle, so dear to the hearts of the so-called practical men, and has put in its place the rule-of-brain. In his calling nothing less than high moral courage and stainless integrity is accepted. If he undertakes to do work for which he knows himself to be unfitted and fails to perform it, punishment is sure and speedy. In no other profession are more important interests involved. On the ships he builds, upon the bridges he constructs, and in the buildings he erects, men intrust themselves, relying upon his skill and knowledge. There is no labor of preparation too hard, no sacrifice of pleasure and enjoyment too great, for him to endure. The lawyer when defeated may always reply that he had a bad case or that one side was bound to lose. The physician may, after making a stupid blunder, bury his mistake; but the mistakes of an engineer bury him.

ELECTRICAL NOTES.

The determinations in the experiments conducted by J. E. Burbank on electrical conductivity of air at sea, the results of which appeared in Terrestrial Magnetism, were made with Gerdien's instrument. A large number of the experiments were made at sea, the times, positions, conditions, and values obtained being given in tabular form. The values of the specific conductivity range from 0.05×10^{-4} up to 2.45×10^{-4}. The most remarkable effects were obtained on July 8, 1905, when on passing into a thick fog the figures fell from 0.40 to 0.05, rising to 1.09 as the fog cleared.

The Chicago City Railway Company give, in a booklet issued by them, data concerning hot-water *versus* electric heating. The chief comparative figures are as follows: Weight of heaters: hot water, 1,454 pounds; electric, 360 pounds. Price of heaters: hot-water, $140 per car; electric, $80 per car. Repairs: hot-water heaters, 10 cents per car per day; electric, 5 cents. Attendance on hot-water heaters, 10 cents per car per day. On these figures the cost per day of heating season works out at 80 cents per car for the hot water, and 73 cents for the electric heaters, including interest, hauling dead weight, repairs, and attendance. The electric heaters are taken as using 12 amperes per car for nine hours = 54 kilowatt-hours per day, and energy is taken at 0.992 cent per unit. Electric heating has been adopted as a result of the saving of 7 cents per car per day shown by the tests.

In U. Majoli's experiments with imperfect electrical contact, a platinum wire is laid carefully across two parallel and horizontal similar wires, and a battery and electric bell are placed in series with these; the resistance at the contact is then sufficiently great to prevent the ringing of the bell, but on producing an oscillatory spark discharge in the neighborhood the resistance falls and the bell rings. This state continues indefinitely unless the wires be shaken. A similar effect may be produced by raising the junctions, one after the other, to a red heat, the interval that elapses between the heating of the two being immaterial, although the wires may be subjected to shaking. Performing a similar experiment with a broken filament inside an incandescent lamp, a similar result may be obtained with the spark discharge, provided that the external resistance is increased considerably, but on admitting air the phenomenon becomes as well marked as in the case of platinum. The author concludes that the contact resistance is due to a film of gas between the conducting surfaces. In a note added at a later date, says N. Cimento, the author describes experiments with an oxidizable metal (iron), from which he concludes that the resistance is due to the film of oxide, and falls considerably when the oxide is reduced.

Considerable care should be exercised as to relative positions of the cranks, the flywheels, and the alternators. If it can be arranged it is desirable to build up the armature of the alternator on the flywheel itself, or at any rate directly couple it to the flywheel, without passing the strain through separate keys on the shaft. Such an arrangement works in very nicely when the cylinders can be arranged on either one or two cranks. Should there be four cranks, as in a vertical four-cylinder engine, it would seem desirable to use a similar arrangement, and only have one flywheel at the same end as the alternator. A considerable number of such engines have been made with a flywheel at each end, an arrangement which does not commend itself to the writer, as vibratory strains might be started up in the crankshaft itself, which under certain circumstances may be so serious as to cause fracture to the shaft. A very satisfactory method of coupling either an alternator or a continuous-current machine to a gas engine is to do so by means of an elastic coupling. It is true that the cost is slightly increased, and that a larger floor space will be necessary; but this method possesses not only the great advantage of reducing the trouble of keeping so many bearings in line, but also gives a little more elasticity in the drive, and prevents risk from short-circuiting. These are advantages which more than compensate for the slight increased cost and space occupied.

After the St. Maurice-Lausanne power transmission plant (20,000 volts direct current) had been placed in operation, the Company of Electrical Industry, of Geneva, Switzerland, undertook a series of interesting experiments with three 20,000-volt direct-current machines, in order to determine the possibility of attaining a tension of 60,000 volts in constant-intensity electric plants. These experiments having given satisfactory results, the Moutiers-Lyons electric power transmission plant (108 miles in length), which is being completed at the present moment, was designed for a pressure of 56,000 to 57,000 volts. In view of the encouraging results obtained in this connection, the Electrical Industry Company are continuing their tests in the presence of Swiss, French, and English engineers on direct currents of even higher pressures. It is thus possible for the first time to observe the effects of direct current at pressures approaching 100,000 volts between the line and the ground, corresponding to a pressure of 200,000 volts between the wires in the case of a power-transmission plant. It should be remembered in this connection that the highest pressure attained in the case of alternating current is 60,000 volts, a figure which is, however, considered by many electricians as excessive. The experiments in question will no doubt greatly increase the possibilities of long-distance power transmission, without the drawbacks inherent in the use of alternating currents.

ENGINEERING NOTES.

During the St. Louis exhibition eight locomotives were tested, these including American, French, and German engines, both simple and compound, for freight and passenger service. These tests were made to show the performance of both engines and boilers, both at average and maximum conditions, and some very interesting results were obtained.

In shops producing pieces by the thousand, such, for example, as bicycle factories, sewing machines, standard lathes, and a thousand and one small articles of every description, the general practice is to install special machines for every individual operation, with always the result of cheapening cost. Another imperative addition to all up-to-date machine shops is the traveling crane. Its value can hardly be overestimated; time and labor are saved to pay for the installation many times over. Practically all traveling cranes are electrically operated, and they are usually so equipped that there is motion in three planes at once. The use of the electric magnet for lifting in connection with these cranes should be made with reserve. It is, however, of much service in some places where the crane travel is small. Small electric or pneumatic jib cranes or suspended hoists should be installed wherever there is much lifting in one particular spot.

Daimler is generally considered to have been the first man to produce an internal combustion engine suitable for road vehicles and for marine propulsion. Born in 1835 at Schorndorf, in Würtemburg, he exhibited a keen interest in mechanics from his youth upward, and made them his constant study. He was first employed at a gun factory in Alsace and afterward at a steam locomotive works in Manchester, finally becoming assistant to Dr. Otto. It was after Daimler had joined Otto that the latter produced the now famous "Otto" gas engine, although it is not claimed that Daimler took part in the invention of it. In 1886 Daimler fitted a launch with an internal combustion engine, and took eleven persons for a voyage on the lake at Canstatt. The engine of this boat had a single cylinder, and developed about one horse-power. It was from the design of this motor that De Dion evolved the high speed engine fitted to his early tricycle. The second launch engined by Daimler in 1887 had a motor of 4 horse-power, which differed from that fitted to the first launch in that it had two cylinders, inclined together at an angle of about 15 seconds, working on a common crank, and was known as the "V" type. This type of engine was first constructed by Daimler in 1886, being then fitted to a road vehicle. It was first publicly exhibited at the Paris Exhibition of 1889.

The relative speeds of two belt-connected pulleys is an every day problem in power transmission, said Mr. W. W. Bird before the New England Cotton Manufacturers' Association. The solution of the problem is very simple if "somewhere near right" is good enough. If a 4-foot pulley making 100 revolutions per minute drives a 1-foot pulley, then the smaller pulley will make 400 revolutions per minute according to the rule that the ratio of the speeds is inversely as the ratio of the diameters. To be more accurate, it is necessary to consider the thickness of the belt and the crown of the pulleys; assuming that the correction for this increases the diameter of each pulley ¾ of an inch, then the smaller one would make 390.9 revolutions per minute, or a difference of more than two per cent. This correction is generally made by taking the diameter of the pulley on the crown for the pitch diameter, with no allowance for the thickness of the belt. The correction, however, to be more accurate, should be made by taking for the pitch radius of the pulley the distance from the center to the middle of the belt at the mean diameter of the pulley. That is, average the diameter of the pulley at the crown with the diameter at the edge of the belt and add the thickness of the belt; this gives the pitch diameter. And the speeds of any two connected pulleys are inversely porportional to the pitch diameters.

A good deal has been heard from time to time of the failure of sewage farms to perform the functions expected of them, and there has, of late, been a tendency in some quarters to turn somewhat hastily to other modes of treatment. The practical application of recent advances in bacteriological knowledge has, however, given a new and increasing interest in the scientific purification of sewage on the greatest of all bacteria beds, the land. That there have been many failures cannot be disputed, but when the causes of such are suitably investigated in the light of present knowledge, it will be at once apparent that no other result could fairly be anticipated. In the great majority of cases, failure efficiently to purify has been due to some one or more of the following causes: The biological principles involved are not infrequently entirely disregarded, and due attention is not paid to the capacity of the land in respect of the quantity of sewage that can be satisfactorily dealt with thereon. Another fault commonly met with is that of localizing the sewage upon certain parts only of the total sewageable area, while the remaining areas are reserved for cropping and profit-earning purposes; in other words, the various areas are not sufficiently alternated in periods of work and rest. Former sewage "filters" failed by choking owing to want of appreciation of the necessity for alternating periods of *rest*, and all land re-

quires like opportunities for the proper digestion of the impurities brought upon it. Suitable cropping is an aid to purification and especially to the recovery or cleansing of land which has become "sewage sick" through being over-worked with sewage.

TRADE NOTES AND FORMULÆ.

Preservation of Chemicals in Amateur Photography.—The developers, such as potash, uranium nitrate, caustic alkalies, sulphites, green vitriol, ammonium rhodanite, etc., are easily oxidized by air, and should be kept in bottles with paraffined corks. All acids and caustic chemicals should be kept in bottles with ground-glass stoppers, also potassium cyanide, eosine, silver nitrate, and solutions of chloride of gold and chloride of platinum; it is advisable to have dark-colored bottles for these last-mentioned chemicals, or to keep them in the dark.—Wiener Mitteilungen.

Cement for Marble.—12 parts of Portland cement, 6 of slaked lime, 6 of fine sand, and 1 of infusorial earth, worked into a thick paste with water-glass (sodium silicate). The cement is to be applied cold, and the fractures or surfaces closely fitted together. It will harden in 24 hours, and the cemented place will be stronger than the rest of the marble, it being impossible to break it at that point. Another marble cement consists of 1 part of a saturated solution of India rubber in chloroform and 2 parts of a concentrated solution of sodium silicate, with the addition of a little powdered slaked lime, marble, and alabaster, pulverized, and fine white sand. To be applied cold.—Schweizer Uhrmacher-zeitung.

Blanching.—The so-called blanching process is employed for silver articles. If the silver were absolutely pure, it would not be changed even by red heat, as the silver has no tendency to oxidize. But since, on account of its softness, it is always alloyed with copper, a film of copper oxide appears when it is heated. If the silver, thus coated, is now heated in dilute sulphuric acid, the copper oxide is dissolved, and the pure metal brought out. This method is also used for bringing more silver to the surface of silver ware, and giving it a purer white color. The article is brought to red heat in the air, whereby the copper of the surface is burned to copper oxide, while the silver remains unchanged. By removing this oxide, through the action of sulphuric acid, the surface will be left with more pure silver than the rest of the alloy.—Metallarbeiter, Vienna.

To Transfer Lithographs to Metal Plates.—The plates are first painted over with an oil paint, and rubbed down with pumice stone, to make the surface perfectly even. Then they are primed with some color, again rubbed with pumice stone, and coated over with the best East India copal varnish. This coat of varnish is partially dried, but not beyond the point where it will adhere to the finger, which will take about three hours. The picture or printing which is to be transferred to the plate is previously laid into dilute aqua regia, and left for 24 hours, then dried between sheets of blotting paper. After drying, it is laid picture side down upon the plate, pressed against the sticky varnish with a wad of cotton for about five minutes, and slightly moistened. Then the paper is rubbed off with cotton, and the picture alone remains upon the plate. It is now coated with copal varnish and thus fixed.—Metallarbeiter, Vienna.

Cracks in Boiler Plate.—Prof. Bach, of Stuttgart, in the Zeitschrift des Vereins deutscher Ingenieure, treats of cracks in boiler plate, referring to cases already in part made public by the German associations for inspection of boiler plate. It was formerly supposed that such cracks were due to imperfect construction, wrong treatment of the plate during manufacture, or unfavorable influences acting upon the boiler when in use. It has now been shown that they result from unsuitable character of the materials. Although the plate, in all cases tried, came up to the fixed standard of tensile strength, great variation of chemical composition was exhibited in the fracture, with considerable content of sulphur, phosphorus, arsenic, and copper, and unusual deterioration of its properties with increasing heat, this sometimes showing itself at 392 deg. F. It is supposed that the formation of cracks is also aided by the choice of overlapping riveting and holes for rivets.

Decalcomania or Transfer Pictures for Ceramic Work.—In the use of transfer pictures for pottery, an important part is played by the substances which serve as a binding medium for the colors and as a soluble stratum between paper and color layer. Whether the pictures peel off, or become displaced, or whether they are properly transferred, depends in no small measure upon the behavior of these substances in the firing process. The binding mediums generally used have various faults. Some, as mucilage and dextrin, become brittle on drying and heating, and crumble in pieces; others become powdery; and others, as oils and varnishes, melt and float off, bringing the picture out of place. It has been found that all the requirements are fulfilled by a mucilage prepared from Irish moss. This remains, even to charring, a tenacious, varnish-like layer, does not peel off or melt, and effects a perfect reproduction of the picture. Its characteristics can be modified by the addition of various agents known in ceramics, as, for example, by sugar. A good medium, which has been tested, is prepared from 100 parts, by weight, of water and 200 of the mucilage to which, after separation of all residue, 300 parts of burnt sugar are added. The same medium will serve for the water-soluble layer, alone or with other layers.—Neueste Erfindungen.

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